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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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10th July, 1917. H 291

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THE WHIRLING AND TRANSVERSE VIBRATIONS OF A ROTATING AIR-SCREW AND ITS SHAFT.

By A. FAGE, A.R.C.Sc.

THE present paper gives the mathematical theory of the transverse vibrations of a rotating air-screw and its shaft, and also an application of the method to several practical problems. For generality, the calculations have been made for a two-bladed air-screw when the transverse vibrations are in a plane parallel to both the axis of the air-screw blades and the axis of rotation, and also when in a plane at right angles to the axis of the air-screw blades and parallel to the axis of rotation. The dependence of the frequency of the transverse vibrations on the length of the shaft, and also on the speed of rotation, has also been determined. Finally, by the elimination of quantities which only slightly influence the value of the frequency of the transverse vibrations, a moderately accurate working formula has been evolved, from which the whirling speed of a rotating air-screw and shaft may be readily calculated. The whirling speed of a modern air-screw as now mounted on the engine of an aeroplane is very high and very much greater than the bursting speed of the air-screw. The mathematical theory of the transverse vibrations of rotating systems is given by Dr. Chree in the Proceedings of the Physical Society of London (1903–5).

In order that the present paper may be complete it is desirable at the outset to indicate the relationship between the frequency of the lateral transverse vibrations and the whirling speed. Taking the simple case of a shaft of negligible mass, fixed at one end and carrying a mass M at the other, it can easily be shown, if $\frac{p}{2\pi}$ be the frequency of the transverse vibrations of the mass M when the shaft is not rotating, and $\frac{q}{2\pi}$ the frequency of the transverse vibrations when the shaft is rotating with an angular velocity ω, that $q^2 = p^2 - \omega^2$.

The elastic forces of the shaft tend to restore the mass to its equilibrium position, but the centrifugal force acting on the mass has the opposite tendency, and by reducing the magnitude of the righting force diminishes also the frequency of vibration of the rotating mass and shaft. If ω be equal to p, the frequency of the transverse vibrations is zero, so that the mass is in neutral equilibrium no matter what the value of the lateral displacement may be, and hence if the lateral displacement be sufficiently great the shaft will fracture. A shaft in such a state is said "to whirl," the righting force due to the elasticity of the system having been reduced to zero by the centrifugal force called into being by deflection. For this particular instance the frequency of rotation when the shaft is whirling, and the frequency of the transverse vibrations when the shaft is not rotating, have equal values, but this is not the case with a rotating air-screw and shaft in which moments of inertia and damping need consideration.

TO FIND THE FREQUENCY OF THE TRANSVERSE VIBRATIONS OF A ROTATING AIR-SCREW AND SHAFT.

The following investigation is an application of Lagrange's equations for small oscillations.

An instantaneous position of the rotating and vibrating air-screw and shaft is shown in Fig. 1, the plane of vibration of the shaft being coincident with the plane of the paper. It is assumed that the air-screw shaft is fixed in direction at the end O, so that the line O X represents the mean position of the vibrating shaft, and also the axis about which the rotation is taking place.

The following symbols are used in the investigation :—

- L = Length of the shaft in feet.
- M = Mass of the airscrew in slugs.
- m = Mass of the shaft in slugs per ft. run.
- I_1 = Moment of inertia of the air-screw about the axis CA in slug-ft.^{2}.
- I_2 = Moment of inertia of the air-screw about an axis through C at right angles to the plane of bending.
- I_3 = Moment of inertia of the air-screw about an axis through C in the plane of bending and at right angles to CA.
- ω = Speed of rotation of the air-screw in radians per second.
- E = Young's modulus of elasticity in pounds per square foot.
- I = Moment of inertia of a cross-section of the shaft about a diameter measured in ft^4.
- x = Distance from 0, in feet, of any point P on the axis of the shaft.
- y = Deflection, in feet, of the point P from the line O X.

At any time t the free end of the shaft is displaced a distance z from its mean position, and the plane of the air-screw has an angular displacement θ from its mean position.

The equations of motion are expressed in terms of the variables θ and z.

From the above remarks it follows that when

$$x = 0, \frac{dy}{dx} = 0 \text{ and } y = 0,$$

when

$$x = L, \frac{dy}{dx} = \theta \text{ and } y = z.$$

So that the equation of the curve of the centre line of the shaft is

$$y = \left(\frac{3z - \theta L}{L^2}\right) x^2 + \left(\frac{\theta L - 2z}{L^3}\right) x^3.$$

Lagrange's equations for a damped vibrating system in which there are two variables, θ and z, are

$$\frac{\delta}{\delta t}\left(\frac{\delta T}{\delta \dot\theta}\right) - \frac{\delta T}{\delta \theta} + \frac{\delta V}{\delta \theta} + \frac{\delta F}{\delta \dot\theta} = 0$$

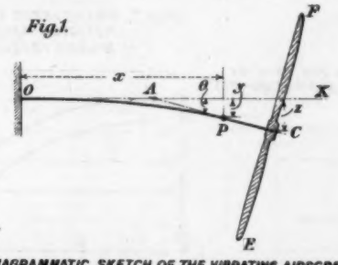
and

$$\frac{\delta}{\delta t}\left(\frac{\delta T}{\delta \dot z}\right) - \frac{\delta T}{\delta z} + \frac{\delta V}{\delta z} + \frac{\delta F}{\delta \dot z} = 0$$

where T = kinetic energy of the whole system.
V = potential energy of the whole system,
and F = half the rate at which energy is being dissipated.

For the case of a vibrating air-screw and shaft

Fig. 1.



DIAGRAMMATIC SKETCH OF THE VIBRATING AIRSCREW. PLANE OF VIBRATION COINCIDENT WITH PLANE OF PAPER.

EF = Axis of Airscrew Blades.
(SCALE)

the kinetic energy of the whole system is equal to the kinetic energy of the shaft + the kinetic energy of the air-screw.

$$= \int_0^L \frac{I}{2} m\,dx\left[\dot y^2 + (y\omega)^2\right] + \frac{M}{2}\left(\dot z^2 + \omega^2 z^2\right) + \frac{I_1}{2}\omega^2\cos^2\theta + \frac{I_2}{2}\omega^2\sin^2\theta + \frac{I_3}{2}\dot\theta^2.$$

$$= \left\{\begin{aligned} &\frac{m\omega^2 L}{2}\left[\frac{I}{5}(3z-\theta L)^2 + \frac{I}{3}(3z-\theta L)(\theta L - 2z) + \frac{I}{7}(\theta L - 2z)^2\right] \\ &+ \frac{mL}{2}\left[\frac{I}{5}(3\dot z - \dot\theta L)^2 + \frac{I}{3}(3\dot z - \dot\theta L)(\dot\theta L - 2\dot z) + \frac{I}{7}(\dot\theta L - 2\dot z)^2\right] \\ &+ \frac{M}{2}(\dot z^2 + \omega^2 z^2) + \frac{I_1\omega^2}{2} + \frac{I_2}{2}(\dot\theta^2 - \omega^2\theta^2) \end{aligned}\right\}$$

since $I_1 = I_2 + I_3$ and $\sin\theta = \theta$ nearly.

The potential energy, V, of the system is equal to the potential energy of the shaft =

$$\int_0^L \frac{EI}{2}\left(\frac{d^2y}{dx^2}\right)^2 dx.$$

$$= \int_0^L \frac{EI}{2}\left[\frac{2}{L^3}(3z - \theta L) + \frac{6x}{L^3}(\theta L - 2z)\right]^2 dx$$

$$= \frac{2EI}{L^3}\left[3z^2 - 3z\theta L + \theta^2 L^2\right]$$

Owing to the vibratory motion of the air-screw blades through the air, energy is dissipated, the rate of such dissipation—2 F—being equal to K $\dot\theta^2$, where K is a constant. The value of the damping factor K can be readily calculated when the aerodynamical data of the blade sections of the air-screw and also the working conditions of the air-screw are known, but it may be of some interest to explain in general language why the rate at which energy is dissipated is proportional to the square of the angular speed of vibration.

Consider the vibratory motion of the blades about an axis through C (Fig. 1) at right angles to the axes of the air-screw and of the air-screw blades, the air-screw having the forward translational speed of the aeroplane, and a rotational speed about the axis O X of ω radians per second. For any positive value of the angular velocity $\dot\theta$, the thrust on the blade C F, which is moving into the air with a velocity greater than that due to the motion of the aeroplane alone, is diminished, whilst the thrust on the blade C E is increased, the change of thrust of an aerofoil section of the blade being roughly proportional to the change of angle of incidence of the section relatively to the air. As a first approximation the change of the angle of incidence of a blade section is proportional to $\dot\theta$, so that the change of thrust of the blade and therefore also the damping moment on the air-screw is proportional to $\dot\theta$. Writing the damping moment as K $\dot\theta$ the rate at which energy is dissipated becomes K $\dot\theta^2$. It will be shown later that the damping moment does not appreciably influence the frequency of the transverse vibrations. Hence

$$F = \frac{K\dot\theta^2}{2}$$

where K is a constant.

Substituting the above values of T, V and F in the Lagrangean equations we get :

$$I_2\ddot\theta + \frac{mL^2}{210}\left(2L\ddot\theta - 11\ddot z\right) - \frac{m\omega^2L^2}{210}\left(2L\theta - 11z\right) + I_2\omega^2\theta + \frac{2EI}{L^3}\left(2\theta L^2 - 3zL\right) + K\dot\theta = 0$$

and

$$M\ddot z + \frac{mL}{210}\left(78\ddot z - 11L\ddot\theta\right) - \frac{m\omega^2L}{210}\left(78z - 11L\theta\right) - Mz\omega^2 + \frac{2EI}{L^3}\left(6z - 3\theta L\right) = 0$$

Which when collected in a convenient form, become

$$\left[\left(I_2 + \frac{2}{210}mL^3\right)D^2 + KD + \left(I_2\omega^2 - \frac{2}{210}m\omega^2L^2 + \frac{4EI}{L}\right)\right]\theta - \left[\frac{11}{210}mL^2D^2 + \left(\frac{6}{L^2}EI - \frac{11}{210}m\omega^2L^2\right)\right]z = 0$$

and

$$-\left[\frac{11}{210}mL^2D^2 + \left(\frac{6EI}{L^2} - \frac{11}{210}m\omega^2L^2\right)\right]\theta + \left[\left(M + \frac{78}{210}mL\right)D^2 + \left(\frac{12EI}{L^3} - M\omega^2 - \frac{78}{210}m\omega^2L\right)\right]z = 0$$

So that the complete motion is given by the solution of the differential equation :

$$\left.\begin{aligned} &\left[\left(I_2 + \frac{2}{210}mL^3\right)D^2 + KD + \left(I_2\omega^2 - \frac{2}{210}m\omega^2L^3 + \frac{4EI}{L}\right)\right] \\ &\left[\left(M + \frac{78}{210}mL\right)D^2 + \left(\frac{12EI}{L^3} - M\omega^2 - \frac{78}{210}m\omega^2L\right)\right] \\ &- \left[\frac{11}{210}mL^2D^2 + \left(\frac{6EI}{L^2} - \frac{11}{210}m\omega^2L^2\right)\right]^2 \end{aligned}\right\}\theta = 0$$

Owing to the large number of algebraic terms—several of them having negligible values—no advantage is to be gained by attempting to solve the differential equation of the fourth order in its present form. By the substitution of the numerical values of the symbols the equation may be written in the form

$$(D^4 + A_1D^3 + A_2D^2 + A_3D + A_4)\theta = 0$$

where A_1, A_2, A_3, A_4 are numerical constants. For all practical purposes the values of A_1 and A_3 are each equal to zero, so that the equation is reduced to $(D^4 + A_2D^2 + A_4)\theta = 0$.

The air-screw and shaft commence to whirl when the frequency of one of the transverse vibrations just becomes zero, so that at the whirling speed the solution of the equation

$$(D^4 + A_2D^2 + A_4)\theta = 0$$

becomes

$$\theta = B_1 + B_2t + B_3\sin\beta t + B_4\cos\beta t$$

where B_1, B_2, B_3 and B_4 are arbitrary constants depending on the initial conditions. For a rotational speed less than the whirling speed the motion consists of two vibrations, whilst at a rotational speed greater than the whirling speed the motion is compounded of a vibration, a divergence and a subsidence, so that if the divergence is allowed to persist the shaft fractures.

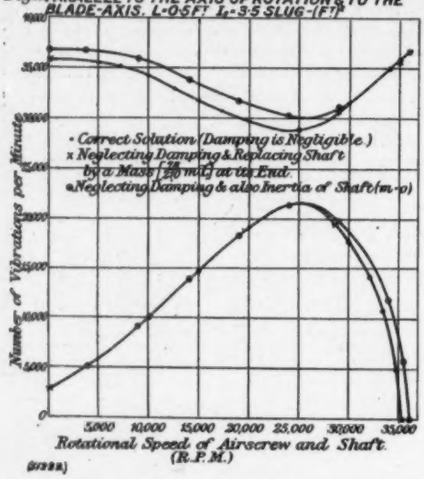
APPLICATION OF THE PRECEDING THEORY TO SEVERAL PRACTICAL PROBLEMS.

With the object of simplifying the differential equation of the motion of the vibrating air-screw

and shaft a systematic series of calculations has been made to ascertain how the frequency of the vibrations depends upon the damping, the mass and the length of the shaft, the mass and the moment of inertia of the air-screw.

The following data, which are needed in the calculations, have been taken from a modern two-bladed air-screw, which, rotating at about 1,300 r.p.m., would give a machine weighing 1 ton a forward speed through the air of 75 miles per hour, the corresponding thrust being 300 lb., approximately.

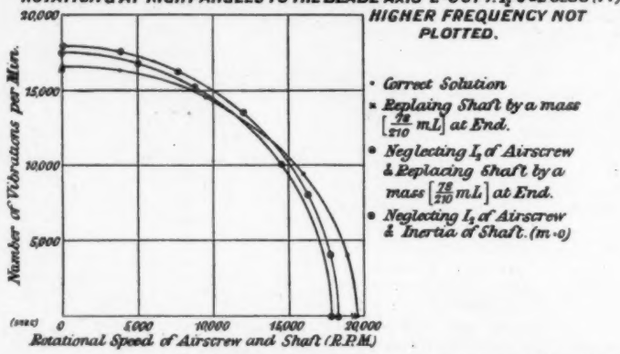
Fig. 2. TRANSVERSE VIBRATIONS IN A PLANE PARALLEL TO THE AXIS OF ROTATION & TO THE BLADE-AXIS. L=0·5 FT. I_2=3·5 SLUG-(FT)^2


• Correct Solution (Damping is Negligible)
× Neglecting Damping & Replacing Shaft by a Mass [78/210 m L] at the End.
• Neglecting Damping & also Inertia of Shaft (m=0)
Number of Vibrations per Minute
Rotational Speed of Airscrew and Shaft (R.P.M.)

(21228)

that the frequency of the transverse vibrations of the air-screw as mounted in practice is very high, much higher than the bursting speed of the air-screw, which is about 3,500 r.p.m., and, accordingly, calculations were made for the air-screw mounted at the end of a shaft of length 2.5 ft. As stated at the commencement of the investigation it is assumed that the air-screw shaft is rigidly fixed at one end, but it is uncertain how far such a condition holds in practice, much depending on the rigidity of the engine frame and the method of mounting the air-screw shaft. Any want of rigidity at the end of the shaft will reduce for the same speed of rotation the frequency of the transverse vibrations. If the end conditions are different from those

Fig. 3. TRANSVERSE VIBRATIONS IN A PLANE PARALLEL TO THE AXIS OF ROTATION & AT RIGHT-ANGLES TO THE BLADE AXIS L=0·5 FT. I_1=0·02 SLUG-(FT)^2 HIGHER FREQUENCY NOT PLOTTED.


• Correct Solution
× Replacing Shaft by a mass [78/210 mL] at End.
• Neglecting I_1 of Airscrew & Replacing Shaft by a mass [78/210 mL] at End.
• Neglecting I_1 of Airscrew & Inertia of Shaft. (m=0)
Number of Vibrations per Min.
Rotational Speed of Airscrew and Shaft (R.P.M.)

(21228)

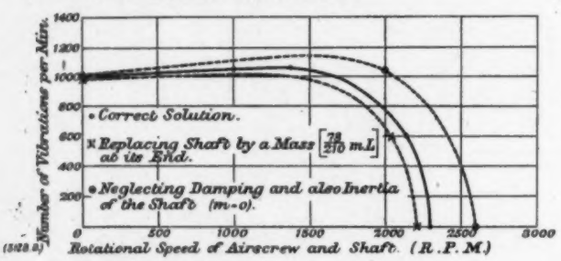
quency of the transverse vibrations may be employed, although the equation of the centre line of the shaft will be different.

The solution of the biquadratic $D^4 + A_1 D^3 + A_2 D^2 + A_3 D + A_4 = 0$ was greatly facilitated by the fact that the terms A_1 and A_3 are of small importance compared with A_2 and A_4, so that the biquadratic could be readily split into two quadratic equations by the method of trial and error. Of course the solution of the biquadratic equation when the damping terms A_1 and A_3 are neglected is a matter of no difficulty.

From the data of the tables and figures it will be seen that the following conclusions may be drawn :—

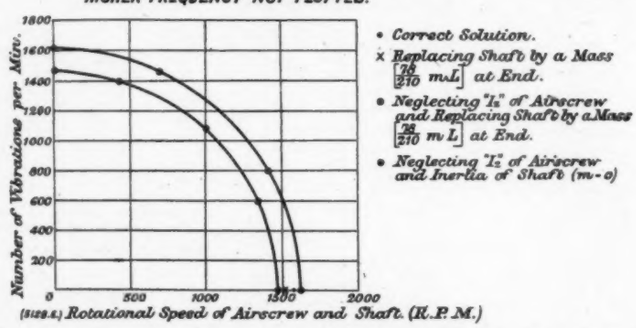
(*a*) The air damping of an air-screw is negligible,

Fig. 4. TRANSVERSE VIBRATIONS IN A PLANE PARALLEL TO THE AXIS OF ROTATION AND TO THE BLADE-AXIS. L=2·5 FT. I_2=3·5 SLUG-(FT)^2 HIGHER FREQUENCY NOT PLOTTED.


• Correct Solution.
× Replacing Shaft by a Mass [78/210 m.L] at its End.
• Neglecting Damping and also Inertia of the Shaft (m=0).
Number of Vibrations per Min.
Rotational Speed of Airscrew and Shaft. (R.P.M.)

(21228)

Fig. 5. TRANSVERSE VIBRATIONS IN A PLANE PARALLEL TO THE AXIS OF ROTATION AND TO THE BLADE-AXIS. L=2·5 FEET. I_2=0·02 SLUG-(FT)^2 HIGHER FREQUENCY NOT PLOTTED.


• Correct Solution.
× Replacing Shaft by a Mass [78/210 mL] at End.
• Neglecting "I_1" of Airscrew and Replacing Shaft by a Mass [78/210 m L] at End.
• Neglecting "I_2" of Airscrew and Inertia of Shaft (m=0)
Number of Vibrations per Min.
Rotational Speed of Airscrew and Shaft. (R.P.M.)

(21228)

Diameter of the air-screw = 9.5 ft.
Mass of the air-screw and metal fittings at the boss, M = 1.0 slug.
Outside diameter of the air-screw shaft = 2 in.
Inside diameter of the air-screw shaft = 0.9 in.
Whence moment of inertia of a section of the air-screw shaft about a diameter = 0.362×10^{-4} ft.^{4}.
Length of the air-screw shaft, L = 0.5 ft.
Mass of 1 ft. length of the air-screw shaft, m = 0.26 slugs.
Modulus of elasticity $E = 4.17 \times 10^9$ lb. per square foot.
Moment of inertia of the air-screw about an axis passing through the centre of the boss at right angles to both the air-screw axis and the blade axis = 3.5 slug-ft.^{2}.
Moment of inertia of the air-screw about the blade axis = 0.02 slug-ft.^{2}.
Hence

$$I_2 = 3.5 \sin^2 a + 0.02 \cos^2 a$$

Where a = angle between the blade axis and an axis passing through the centre of the boss at right angles to the plane of vibration.

Only the two extreme values of I_2 were taken, namely, 3.5 when $a = 90$ deg. and 0.02 when $a = 0$ deg.

The rate at which energy is dissipated for this air-screw is 150 $\dot{\theta}^2$ ft.-lb. per second, when $a = 90$ deg. The damping when $a = 0$ deg. can be neglected at the commencement of the investigation.

The calculations are quite straightforward, although somewhat laborious, and it has been considered not desirable to overburden this paper with the complete calculations, so that only a summary of the results is given in the tables and shown graphically in the figures. It will be noted

TABLE I.—*Summary of the Results of the Calculations made on a Modern Two-bladed Air-screw, Mounted as in Practice on a Shaft of Length 0.5 ft.*

Case I.—Transverse vibrations in a plane parallel to the axis of rotation and to the blade axis. $a = 90$ deg. and $I_2 = 3.5$ slug-ft.^{2}. Bursting speed of air-screw about 3,500 r.p.m.

Assumptions made in Calculations.	Rotational Speed of the Shaft (r.p.m.).	Number of Vibrations per Minute.	
Complete solution, making no assumptions	0	2,770	35,800
	5,000	5,900	35,600
	10,000	10,100	34,200
	15,000	14,800	31,600
	20,000	19,000	29,700
	25,000	21,700	28,800
	30,000	17,800	31,400
	34,000	9,000	34,900
	35,000	0	35,800
Neglecting damping only	Results same as with no assumptions.		
Neglecting damping and assuming effect of shaft to be equivalent of a mass $\left(\frac{78}{210} m L\right)$ at its end	0	2,785	35,800
	28,700	19,400	30,300
	35,100	0	35,600
Neglecting damping and also the inertia of the shaft (m = 0)	0	2,755	36,700
	4,000	5,100	36,700
	9,000	9,200	36,000
	14,000	13,900	33,800
	19,000	18,200	31,700
	24,000	21,500	30,200
	29,000	19,800	30,900
	34,000	12,000	34,900
	36,000	0	36,700

TABLE II.—*Summary of the Results of the Calculations made on a Modern Two-bladed Air-screw, Mounted as in Practice on a Shaft of Length 0.5 ft.*

Case II.—Transverse vibrations in a plane parallel to the axis of rotation and at right angles to the blade axis. $a = 0$ deg. and $I_2 = 0.02$ slug-ft.^{2}. No damping in this case. Bursting speed of air-screw about 3,500 r.p.m.

Assumptions made in the Calculations.	Rotational Speed of the Shaft (r.p.m.).	Number of Vibrations per Minute.	
Complete solution, making no assumptions	0	16,600	78,800
	4,000	16,400	79,000
	10,000	14,400	80,000
	16,000	9,300	81,600
	19,000	3,800	82,700
	19,500	0	82,900
Assuming effect of the shaft to be equivalent to a mass $\left(\frac{78}{210} m L\right)$ at its end	0	16,400	Not calculated.
	19,300	0	
Neglecting I_2, which is very small in this case, and assuming effect of the shaft to be equivalent to a mass $\left(\frac{78}{210} m L\right)$ at its end	0	17,750	
	17,750	0	
Neglecting I_2 and also the mass of the shaft (m = 0)	0	18,150	
	18,150	0	

postulated in the present paper, but are definitely defined, the same method of calculating the frein so far as the frequency of the transverse vibrations is concerned.

(*b*) The whirling speed may be calculated with very good accuracy by assuming the effect of the shaft to be the equivalent of a mass $\frac{78}{210} m L$ at

TABLE III.—*Summary of the Results of the Calculations made on a Modern Two-bladed Air-screw Mounted at the End of a Long Shaft of Length 2.5 ft.*

Case I.—Transverse vibrations in a plane parallel to the axis of rotation and to the blade axis. $\alpha = 90$ deg. and $I_2 = 3.5$ slug-ft.^{2}.

Assumptions made in Calculations.	Rotational Speed of the Shaft (r.p.m.).	Number of Vibrations per Minute.	
Complete solution, making no assumptions	0	1,000	3,640
	500	1,200	3,630
	1,000	1,060	3,620
	1,400	1,070	3,620
	1,800	950	3,650
	2,200	490	3,750
	2,290	0	3,770
Neglecting damping makes practically no difference to the frequency			
Neglecting damping and assuming effect of the shaft to be the equivalent of a mass $\left(\frac{78}{210} m L\right)$ at its end	0	990	3,720
	1,910	760	3,770
	2,220	0	3,780
Neglecting damping and also the inertia of the shaft ($m = 0$)	0	1,020	Not
	1,910	1,095	calcu-
	2,590	0	lated.

TABLE IV.—*Summary of the Results of the Calculations made on a Modern Two-bladed Air-screw Mounted at the End of a Long Shaft of Length 2.5 ft.*

Case II.—Transverse vibrations in a plane parallel to the axis of rotation and at right angles to the blade axis. $\alpha = 0$ deg. and $I_2 = 0.02$ slug-ft.^{2}. No damping in this case.

Assumptions made in the Calculations.	Rotational Speed of the Shaft (r.p.m.).	Number of Vibrations per Minute. Frequency of the Higher Vibrations not Calculated.
No assumptions	0	1,500
	1,565	0
Assuming effect of the shaft to be the equivalent of a mass $\left(\frac{78}{210} m L\right)$ at its end	0	1,480
	1,510	0
Neglecting I_2, which is very small, and assuming effect of the shaft to be the equivalent of a mass $\left(\frac{78}{210} m L\right)$ at its end	0	1,460
	1,460	0
Neglecting I_2 and mass of shaft ($m = 0$)	0	1,620
	1,620	0

its end. In this case the whirling speed is overestimated, the inaccuracy increasing with the length of the shaft. The maximum error due to this assumption is only about 3.5 per cent. of the true value of the whirling speed.

(*c*) As would be expected, neglecting the mass of the shaft makes the whirling speed too high, the discrepancy increasing with the length of the shaft, the maximum error due to the assumption being 13 per cent. of the true value of the whirling speed.

(*d*) It is seen from Figs. 3 and 5 that even when the moment of inertia I_2 of the air-screw is small —0.02 slug-ft.^{2} in this particular case—it should not be neglected in the calculation of the whirling speed.

(*e*) The whirling speed of an air-screw and shaft increases with the moment of inertia of the air-screw.

(*f*) When the moments of inertia of the air-screw —I_2 in this case—and of the shaft are zero, the whirling speed has the same frequency as the natural period of transverse vibration when not rotating.

A SIMPLE FORMULA FROM WHICH MAY BE CALCULATED THE WHIRLING SPEED OF ROTATION OF AN AIR-SCREW AND ITS SHAFT.

It has been shown that the air damping of an air-screw may be neglected, and also that the effect of the inertia of the shaft is equivalent, for all practical purposes, to a mass $\frac{78}{210} m L$ placed at its end. The differential equation for the motion of the air-screw and shaft then becomes

$$\left\{\left[D^2 + \omega^2 + \frac{4EI}{LI_2}\right]\left[D^2 - \omega^2 + \frac{12EI}{L^3\left(M + \frac{78}{210} m L\right)}\right] - \frac{36E^2I^2}{I_2L^4\left(M + \frac{78}{210} m L\right)}\right\}\theta = 0$$

that is

$$D^4 + D^2\left(\frac{4EI}{LI_2} + \frac{12EI}{L^3\left(M + \frac{78}{210} m L\right)}\right) + \left(\omega^2 + \frac{4EI}{LI_2}\right)\left(\frac{12EI}{L^3\left(M + \frac{78}{210} m L\right)} - \omega^2\right) - \frac{36E^2I^2}{I_2L^4\left(M + \frac{78}{210} m L\right)}\Bigg\}\theta = 0$$

The whirling speed, that is, the rotational speed at which the frequency of one of the transverse vibrations becomes zero, is then got from the expression

$$\left[\omega^2 - \frac{12EI}{L^3\left(M + \frac{78}{210} m L\right)}\right]\left[\omega^2 + \frac{4EI}{LI_2}\right] + \frac{36E^2I^2}{I_2L^4\left(M + \frac{78}{210} m L\right)} = 0$$

which may be written

$$\omega^4 + \omega^2\left[\frac{4EI}{LI_2} - \frac{12EI}{L^3\left(M + \frac{78}{210} m L\right)}\right] = \frac{12E^2I^2}{I_2L^4\left(M + \frac{78}{210} m L\right)}$$

If the above equation be solved for ω^2 it will be found that there is one positive and one negative value. The whirling speed may be got by taking the square root of the positive value of ω^2. The result of the present investigation may be summarised as follows.

The critical speed, ω, of a rotating air-screw and shaft, the shaft being a cantilever fixed in direction at one end, may be calculated by taking the square root of the positive value of ω^2 got from the solution of the equation

$$\omega^4 + \omega^2\left(\frac{4EI}{LI_2} - \frac{12EI}{L^3\left(M + \frac{78}{210} m L\right)}\right) = \frac{12E^2I^2}{I_2L^4\left(M + \frac{78}{210} m L\right)}$$

where

ω = rotational speed in radians per second.
M = mass of the air-screw in slugs.
I_2 = moment of inertia of the air-screw about an axis passing through the centre of the air-screw at right-angles to the plane of the transverse vibrations (slug-ft.^{2}).
L = length of the shaft in feet.
m = mass of one foot length of shaft in slugs.
E = Young's modulus in lb. per square foot.
I = moment of inertia of a cross-section of the shaft about a diameter in feet^4.

If $I_2 = 0$ the whirling speed may be calculated from the equation

$$\omega^2 = \frac{3EI}{L^3\left(M + \frac{78}{210} m L\right)}.$$

MANITOBA WATER POWERS.

IN various articles attention has been directed to the wise enterprise Canada has displayed in conserving her rivers, with the view of promoting hydro-electric projects and for utilising the water power at her command in the best conceivable way. It is no less desirable to consider the latent and yet undeveloped resources, as well as the cautious and far-seeing policy by which she prepares for the future, and schemes to ensure to her growing population the fullest returns from the beneficial reservoirs with which she is abundantly supplied. This policy is designed to prevent any frittering away of great opportunities by snatching at results that promise a handsome advantage for the present. New centres of industry, which it should be the object of the Dominion to encourage, will most readily cluster round stations where power is generated on a large scale and made available without stint. The evidence of progress may not be so rapid, but, ultimately, such provident extension, by benefiting the whole community, will reap a rich reward. It brings enlarged opportunities for employment, it gives greater stability to existing prosperity by providing a wider diversity of interests, it offers a firmer foundation on which to build future progress. Manitoba has adopted a policy conceived on these broad lines (not perhaps more markedly than other provinces have done, for all recognise the duty of a judicious husbanding of the known resources, while seeking the development of the dormant on a systematic plan), and it has, by a report issued by the Water Power Branch of the Dominion,* very clearly defined its position.

Manitoba is the more urged to develop these stores of water power owing to a deficiency of coal within the province. The continually increasing cost of a good steam coal was a great inducement to find an adequate substitute, and riparian owners eagerly sought permission to develop the more eligible sites where power could be readily obtained, regardless of future systematic control. Winnipeg River was a most attractive source for the small capitalist; its proximity to the more thickly populated districts ensured a ready sale, and the cost of electric transmission was small. But to grant a number of small leases would have been fatal to the pursuit of a general policy framed in the best interests of the province, and by timely action the legislature has prevented any undue exploitation of the national wealth. The administrative Acts prohibit the sale or conveyance in fee by the Crown of any lands which are required for the protection of any water supply, or which will be required for the working and developing of water power. Such lands may only be leased under regulations made by the Governor in Council. By a method of periodic revision these regulations afford every reasonable protection to the public in the way of limited grants, rentals and control of rates, while at the same time they provide such inducement for investment as to attract the capitalist.

The need for, as well as the beneficial results of, legislation are well illustrated by this same river. With a fall of 271 ft. and an available flow of about 12,000 cub. ft. per second, the utmost power that could be obtained with the natural flow is 237,000 h.p. Under complete regulation, involving the systematic control of the whole river, the regulated flow can be increased to 20,000 second-feet, and the total power capacity (at 75 per cent. efficiency) raised to 409,000 h.p. The war has probably delayed the prosecution of the scheme, which in its entirety embraced storage control at eight distinct power sites within 80 miles of the city of Winnipeg, but a total power capacity of 200,000 24-hour horse power should now be available. The important point is that the future development of the river, with all that this entails on the growing fortunes of the province, being under Government supervision, is removed from the field of chance enterprise and private speculation.

This wholesome and complete control is the more fortunate as, notwithstanding the immense drainage area for which it acts as a basin, Manitoba, at least in its southern and more settled portion, is endowed with comparatively small water powers. Lake Winnipeg, situated in a depression between the prairie steppes and the Laurentian plateau, forms a reservoir into which is collected practically the rainfall from the vast area that extends from the Rocky Mountains on the West to Lake Superior in the east. The northern lands of Western Canada, as well as some portion of the United States, contribute to the waters of this lake system. The consequence of this natural drainage is that the possible sites for water powers become separated into two main divisions, those situated on the rivers draining into Lake Winnipeg, and those that flow outwards towards Hudson Bay. The former, being confined to the southern portion of the province, are those that have been more completely investigated and brought into requisition. With these the head is generally small, while such magnificent streams as the Nelson River, claiming a total fall of 700 ft. between Lake Winnipeg and Hudson's Bay, offer great, but little-known, possibilities. Leaving on one side the Winnipeg and English Rivers, which were sufficiently dealt with in these columns last September, the contrast is well demonstrated by a comparison between the Saskatchewan and the Nelson, which may be regarded as representative of the river systems.

The Saskatchewan drains an area of not less than 155,000 sq. miles. The head waters lie in the distant Rocky Mountains, and the drainage thence to Lake Winnipeg is effected by its various tributaries, which

* "Manitoba Water Powers," by D. L. McLean, S. S. Scovil and I. T. Johnston. Compiled for the Manitoba Public Utilities Commission. Government Printing Bureau, Ottawa.

include the South Saskatchewan. From the point of junction of these two streams, till their joint waters end in Winnipeg, the flow is mostly confined to a single bed, though, owing to the generally flat and low-lying character of the country, this bed may change its position, or divide into secondary channels. Such a country is not favourable to river development, and little attempt has been made to investigate its possibilities till the united river reaches Cedar Lake. Between Cedar Lake and Cross Lake occur the Demi Charge Rapids, while from Cross Lake to Winnipeg, a distance of about 10 miles, a series of rapids offers promising sites at Cross Lake, Red Rock and Grand Rapids. The data at hand are hardly sufficient to decide the extent of possible power development. Accurate measurements of the head and flow available, of fundamental importance in such inquiries, have not been made over an interval long enough to furnish average conditions, or to indicate within narrow limits the extreme and mean stages of the river level. The amount and variation of rainfall are also unknown quantities, though the prevailing conditions suggest that the rainfall is small, probably under 20 in. annually, and that no small portion of it is absorbed by ground flow or lost in summer evaporation. The discharge estimates are equally vague, but flow measurements at Grand Rapids indicate a minimum flow of 5,000 second-feet, while on one occasion a flow discharge of 64,000 second-feet was recorded at Le Pas, some 100 miles up the river. It would be premature without more data than those already collected to decide on the nature or extent of storage facilities, but engineers entertain the possibility of providing a uniform flow of 32,000 second-feet. Accepting the minimum measurements, a storage of 305 billions of cubic feet would be necessary to secure this result, and three lakes, Cross, Cedar and Moose, with a joint area of 503 square miles, afford good promise of the ultimate achievement of such a scheme. The estimated horse-power, on an 80 per cent. efficiency, is exhibited in the following table, calculated both for a minimum flow of 5,000 second-feet throughout the year and for a flow of 34,000 second-feet, this being the lowest monthly mean flow for the six months of greatest discharge, namely, from April to September. No estimate has been made of the additional power available during periods of low flow through any storage system.

Possible Power Site.	Head in Feet.	Minimum Flow. 5,000 Sec.-ft.	Period April–September. 34,000 Sec.-ft.
		horse-power	horse-power
Demi Charge	15	6,808	46,289
Red Rock	15	6,808	46,289
Grand Rapids.. ..	80	36,305	246,877

At present there is no commercial demand for power on this scale, the station being remote from the populated district, and as a storage slightly over 10 ft. throughout these lakes would be necessary to maintain the continuous flow, the scheme will probably remain in abeyance for some time. Meanwhile the Water Branch is collecting an amount of information that will ultimately be useful and is conserving the best interests of the country.

The Nelson River has a length of 430 miles and drops some 700 ft. in its course. It really consists of a chain of lakes of slow-running water, connected by falls or by reaches of river and rapids, that in its upper portion at least, are sharply defined and of steep descent. The banks along much of the route are high, sometimes attaining 70 ft., and rock outcrops occur at all the rapids. The time of high water will naturally occur in the summer, when the snow melts, and that of minimum discharge in the late winter months; but the extreme range between these two periods is stated to be never more than 6 ft. This is explained by the controlling influence of the huge expanse of Lake Winnipeg, more than 9,000 square miles in area, and other great reservoirs in its neighbourhood, operating as a natural regulation on the flow of the river, keeping the range between flood and minimum discharge unusually small. In this respect the Nelson may be compared with the Saint Lawrence, that likewise is furnished with a natural regulation through the action of the Great Lakes.

The actual measurements of flow are scanty, especially of the minimum winter discharge; the inhospitable climate of the upper reaches making such work burdensome. At the Whitemud Falls, 100 miles north of Lake Winnipeg, a discharge of 109,364 second-feet was recorded, and at a station 50 miles further, when the river was considered to be at a very low stage, the amount increased to 118,369 second-feet. In the present dearth of accurate information there is little need for giving a list of stations where it is possible to construct power sites advantageously. The number of these being large, 19 in all, the fall at each is small, only in one case exceeding 50 ft., but the aggregate energy at future disposal is enormous. The engineers have wisely discarded such huge figures as those just mentioned, and have based their estimates on a minimum flow of 50,000 second-feet, at 80 per cent. efficiency. On this modest reckoning the total exceeds 2,500,000 h.p., an amount that surpasses the total available energy of Switzerland and is more than twice as great as the whole developed horse-power of Norway, favourably endowed as is that country.

When treating of the Pinawa Channel development reference was made to the inconveniences arising from ice formation and the necessity of adopting adequate precautions. As in still higher latitudes a more inclement climate is encountered, the annoyance becomes increasingly threatening, but offers no new problem for solution. It must not be forgotten that the temperature of the water, even in the most severe winter, does not vary appreciably from the freezing-point, and that the great difficulties that arise are due to the slight changes in the temperature when varying but a small fraction of a degree. These drawbacks, due to physical conditions, are but little increased with latitude. Surface ice will always give trouble when it cuts off the water supply or raises the tail water. Anchor ice occasions its own inconveniences by rising in masses from the river bottom, bringing stones and boulders with it. The more dreaded frazil ice, formed when the air temperatures are near freezing-point, will ever be harassing and dangerous. The ice crystals, formed by exposure to the cold atmosphere, grow rapidly, adhering to every cold body with which they come in contact. Racks, penstocks, turbines are quickly affected by enormous accumulations that may effectually close down the plant. Science and ingenuity have so far overcome most of the troubles that modern equipment is fairly immune. Surface ice may even be encouraged, to free the waters of frazil, and ice overflows and runways can be planned to carry ice to the tail race. Frazil ice requires further precautions and may entail no inconsiderable expense. Iron racks should be totally submerged, in order that, being of the same temperature as the water, they may not act as conductors: any exposed parts above the water level may be of wood. Iron penstocks, if not buried, and turbine cases should be carefully housed in. Where gates, sluices, stop-log guides, &c., are necessarily exposed, steam heating plants supplying permanently placed steam piping for maintaining freely working equipment have to be applied, or heated air can be blown on the protruding racks. The greater the evil, the greater will be the ingenuity and pertinacity that will find the remedy.

DIRECTORY AND CHRONICLE FOR CHINA, JAPAN, &c.—In the paragraph on page 604 of our last volume we stated by error that the price of this directory is 10*s.* net. This should read 30*s.* net.

INDIA'S COPPER RESOURCES.—Just before the war copper to the value of over 2,000,000*l.* per annum was being imported into India, and a very considerable proportion of this total came from Germany. Yet India itself has copper deposits of no little importance, and the British Empire Producers' Organisation understands that in former days this ore was mined and smelted in considerable quantities in Southern India, Rajputana, and at various places along the outer Himalayas—*e.g.*, Garwhal, Nepal, Sikkim and Bhutan. Chota Nagpur is reported to contain rich lodes of copper. Various companies have exploited the copper ores of India during the last 50 years, but until quite recently the results have been anything but successful—due apparently, to unscientific methods. The Indian Munitions Board have now engaged experts in England to go out to India with the view of developing the industry on scientific lines.

THE WORLD-WIDE RAMIFICATIONS OF THE GERMAN CHEMICAL INDUSTRY.

THE chemical industry of Germany, which some five or six decades ago was an entirely negligible quantity, has since made stupendous strides, and left all competition a long way behind. The only really exhaustive statistics referring to the production of this industry date from 1897, when the annual production represented a value of 947,902,570 marks, exclusive of the different chemical products of the iron and other metal works. In 1906 the output was estimated by experts to have a value of between 1,250,000,000 marks and 1,500,000,000 marks, and for the year 1913 the aggregate value may be taken as very nearly 2,000,000,000 marks (100,000,000*l.*). This shows the chemical industry to occupy the third place as regards value among German industries, only the textile and the metal industries being higher on the list, whilst it is fourth in the matter of exports, electrochemical manufacture, &c., beating it for third place. The exports of chemical and pharmaceutical products and dyes, &c., rose from 200,200,000 marks in 1880 to 352,400,000 marks in 1900, but have been more than doubled during the present century, the aggregate value of the exports amounting to 752,800,000 marks in 1911. This remarkable progress, which German authorities were convinced would have continued, had it not been for the war, is attributed to the intimate combination of science and practice, science penetrating every branch and every detail. To this must be added the advances of theoretical and applied chemistry, a stringent division of labour and an able and harmonious co-operation of all factors concerned from first to last, and above all, character and ability in the chiefs.

France is an important consumer of German chemical products, the import of which in 1902 had a value of 861,600*l.*, and in 1912 of 2,437,760*l.* Although this is no mean figure, it does not by a long way represent the actual state of affairs, the Germans having established a number of factories within France, to a great extent from considerations connected with the maintenance of patents, &c. As a German factory in France, which has kept its German name, may be mentioned the Société Anonyme des Anciens Etablissements Weiler-ter-Meer, at Tourcoing, near Lille, a daughter concern of the Weiler-ter-Meer firms at Uerlingen. The products comprise sulphuric acid, nitric acid, &c., and a comprehensive list of aniline dyes. Another example is that of the chemical works, H. and E. Albert, of Amöneburg, near Biebrich, which firm has branches under the German name in Homécourt, Villerupt, Neuves-Maisons and Pompey. The manufacture comprises superphosphates, Thomas meal, &c., and a number of agricultural, chemical, and pharmaceutical products. The chemical factory of Griesheim-Elektron, Frankfort-on-the-Main, has followed another method. The firm was originally started in 1856, and has now a capital of 14,000,000 marks. The principal manufacture consists of mineral acids, soda, bichromate, aniline goods, potash, &c. The company, in addition to its chief factory at Griesheim-on-the-Maine, has factories at Bitterfeld, Küpersteg, near Cologne, Spandau, Offenbach, and Giewitz, besides being a partner in the Duisburger copper works, the Sociedad Electroquimica de Flix, in Barcelona, and the Société Industrielle de Produits Chimiques at Lamotte-Breuil (Department Oise). This latter company was formed in 1896 for a period of 50 years. The share capital to begin with amounted to 80,000*l.*, and has since been raised to 100,000*l.* The company was formed for the manufacture of chemical products in France, and eventually abroad. The board, in the first instance, consisted of French and Swiss shareholders, but since then the financial preponderance has gravitated towards the Griesheim-Elektron Company, which has purchased a large proportion of the shares. The production is principally confined to chlorides and alkalies.

The aniline dye industry of Germany is one of those which the war has brought particularly into prominence. The value of the aniline production rose from about 30,000,000 marks in 1874 to 150,000,000 marks in 1898, and from January to October, 1912, the export from Germany of dye-

stuffs amounted to 1,250,000 cwt., representing a value of 224,310,000 marks (11,215,500*l.*).

One of the most important German concerns in this branch is the Badische Aniline and Soda Works, Ludwigshafen, on the Rhine, founded in Mannheim in 1865 and removed to Ludwigshafen two years later. The capital was originally 1,400,000 florins, and is now 36,000,000 marks. The buildings of the works cover 104 acres, and the employees comprise 33 higher officials, 412 engineers, and more than 8,000 hands; these figures are for the year 1912. The production consists of aniline, alizarine, naphthol, resorcin, synthetic indigo and a number of auxiliary dye-stuffs, besides soda, chlorides, sulphuric acid, &c. The company has branch establishments and factories at Butirki, near Moscow, at Christianssand, Norway, and in England. In France there is an agency in Paris and a factory at Neuville-sur-Saône, near Lyons, which has a great sale of the specialities of the mother firm, especially indigo, aniline and alizarine dyes.

Another German firm in the same branch is the Höchster dye works, at Höchst, near Frankfort-on-the-Main. This concern has a number of agencies in France and a factory under the style of Compagnie Parisienne de Coleurs d'aniline at Creil (Oise). The Höchst dye works commenced in the most modest style, with five hands, a clerk and a chemical expert in the year 1863; the Höchst dye works of to-day have a capital of 36,000,000 marks. The company has branches, agencies and depots in almost every country. In France it has agents in almost all large towns—Paris, Lyons, Marseilles, Saint-Etienne, Amiens, Rheims, Nantes, &c. To facilitate the trade, and from patent and customs considerations, a French factory was formed in the year 1881 under the style of Compagnie Parisienne de Coleurs d'aniline, and a couple of years later the firm bought the works of Coupier and Cie, at Tremblay, near Creil.

Also the firm of Casella and Co., Frankfort-on-the-Main, a company with a capital of 20,000,000 marks, and which is closely connected with the Höchst concern, has an affiliated company in Lyons, under the style of Manufacture Lyonnaise de Matières Colorantes, which manufactures the same dye-stuffs as the mother company.

The Company for the Manufacture of Aniline Dyes at Treptow, founded in 1873 by the amalgamation of several firms and with a capital of 14,000,000 marks, has a factory at St-Fons, near Lyons, and factories at Moscow and Libau. The French factory was an old concern, started in the year 1821, and the Treptow company took it over; besides that in Treptow this firm has other factories at Wernsdorf, Kiekemahl, Greppin and Bitterfeld.

The Mülheim Dye Works, Mühlheim-on-the-Main, with a capital of 2,700,000 marks, has an affiliated company in France. The firm has works in Manchester, Glasgow and Bradford, and in Roubaix.

Of material interest as regards France, both in the matter of dye-stuffs and pharmaceutical articles, is the firm of Fried. Bayer and Co., of Elberfeld. This company, which started in a very small way in 1864, has now a capital of 36,000,000 marks, the same as the two first-named firms. The Fried. Bayer Company has factories at Elberfeld, Leverkusen and Barmen, in Germany, at Fers, near Roubaix, in Moscow, at Schoonaerde in Belgium, at Bromborough in England, and at Albany in the United States. Their manufacture comprises aniline and other dyes, acids, alkalies, photographic articles, &c. In France they are represented by the Société Anonyme des Produits Friedrich Bayer and Co., with domicile at Flers-au-Breux, near Lille, where there are chemical works of some importance. The French factory particularly goes in for the manufacture of pharmaceutical articles, and besides the factory at Flers there is a laboratory in Paris. The manufacture comprises phenacetine, sulphonal, trional, veronal, linninal, iodothyrin, theobromine, &c.

The German chemical industry has achieved great results in France in the domain of pharmaceutical articles, and the specialities of the German chemical industries are found in all French drug shops, and although they are dearer in many instances than the French imitations, the public generally gives preference to the German goods. Thus veronal costs respectively 240 francs or 80 francs per kilogram, if it has the Merck brand or not, and aspirin Bayer costs 50 francs, whereas aspirin "Façon Bayer" only costs 10 francs.

This accounts for a number of German chemical factories, which have no branch works or depots, but at most agencies or selling bureaus, in France, still exporting their pharmaceutical articles to this latter country. In this connection may be mentioned Kalle and Co., Biebrich; Knoll and Co., Ludwigshafen; the Lanoline Factory, Berlin; the South German Chemical Works at Gernsheim, &c. The Œuvre de la Tuberculose Humaine in France uses dioradine from the German and the Austro-Hungarian Dioradine Company. The Swiss pills sold in France are mostly made in Germany, as are numerous medicines; French dentists use preparations from Dr. Speier, Berlin, &c.

The three most important German factories for pharmaceutical articles which have branches in France and rule the French market are the above-mentioned firm of Friedrich Bayer and Co., E. Merck and the Chemical Works, formerly E. Schering. France proved an excellent market for these firms, and as soon as their goods were introduced in the trade they built factories there.

The firm of E. Merck has of old an excellent name, emanating from the Angel Apothecary, erected in 1668 in Darmstadt, which remained in the possession of the Merck family and which has been worked up to the big concern of the present day. The firm has a factory in Morteau (Seine-et-Marne) and branches in London and Moscow.

The E. Schering Chemical Works also started in a small way, the beginning being a modest apothecary's shop in Berlin, 1851, and to this a small factory was added two years later. The company has now a capital of 8,000,000 marks. The specialities were pharmaceutical and photographic articles, and in the year 1897 a house was started in Paris under the style of Helios, Société Anonyme Française de Produits Chimiques et Photographiques. The Helios Company has the exclusive representation of the German firm, and comprises a number of German merchants and industrial experts, most of whom live in France. The Helios Company has published much technical literary matter, under the names of French specialists, about the Schering articles, and carries on in this way a most useful scientific-commercial *réclame*. This firm has also received public encouragement of different kinds.

Another German undertaking with an extensive international connection is the oil mills of Stern and Sonneborn, Limited, in Hamburg. This company was formed in the year 1903 with a capital of 2,500,000 marks, a few years later increased to 3,000,000 marks. The firm also had works in Cologne, and went in for the manufacture of vaseline, industrial oils, &c. In Italy the firm is represented by the Società Anonima Pergli Olii Stern-Sonneborn, with domicile in Genoa, and in England by the Stern-Sonneborn Oil Company, Limited, London. In France the company has founded an affiliated concern, the Société Anonyme Française Stern-Sonneborn, in Paris. The brothers Stern had already a factory in France, which was absorbed by the new company at a price of 319,284 francs, the capital being fixed at 650,000 francs, the shares being taken up partly by the Stern-Sonneborn Company and partly by persons connected in some way with the company, but the French company is entirely under the control of the German company. The French company has attained to an excellent industrial and commercial standing.

In the matter of glue and manure manufacture only one firm calls for notice, that of the Scheidemandel Company for Chemical Products, domiciled in Berlin, which is generally looked upon as a standard example of German industrial expansion, and which has often served as a kind of bogey for people fearing an industrial invasion on the part of Germany. The firm has branch establishments over the whole of Germany, in Austria-Hungary, in Russia, in Switzerland, in Italy, in Belgium, in Spain and in France.

Some twenty years ago the German glue manufacture was confined to a number of minor factories which worked with a modest capital and inefficient plant. In order to increase his capacity and so as to get rid of an unpleasant competition, the small Bavarian manufacturer, H. Scheidemandel, of Landshut, acquired a couple of neighbouring concerns and formed a company for chemical products. This company made such rapid headway that a number of kindred German undertakings joined it, and in 1912 the Scheidemandel Company had the control of 17 German glue factories. As the business gravitated northward, the domicile was removed to Berlin in the year 1904. The company principally goes in for the manufacture of glue, bone fat and bone meal. The latter is used as manure both in and out of Germany, whilst bone fat is one of the principal raw materials in the manufacture of stearine and soap. The company's German works handle annually some 6,000 wagon loads of bones, and the share capital has, by degrees, been raised to 11,000,000 marks. The Scheidemandel Company not only possesses a number of factories, but is also interested in several, and may be said to control the whole of this branch in the German industry. Owing to its great expansion and the nature of the raw materials employed, the Scheidemandel Company naturally soon began to look outside Germany for further extension; as a result the company at the present day has material interests in all kindred industries in all European countries, and even in South America. The leading company of the Austrian Scheidemandel group is the Ossa Company for Chemical Industry in Vienna, which, again, has several branch establishments. The Hungarian group comprises the First Pest Glue and Spodium Company and a company in Cutis, which, again, has some branches. The Belgian group comprises four companies, in Hasselt, Viloorde and Brussels, the Italian group has concerns in Rome, Genoa and Turin. In Switzerland, in Spain, in Russia and in Brazil there are Scheidemandel works.

In France the Scheidemandel Company made rapid progress, in the course of two years securing the control of five French companies (those of Tancrède, Collette, Joudrain, Georget and Verdier-Dufour) and forming them into a combine of four companies. Although these companies are French by name and formed in accordance with French regulations, the German Scheidemandel Company controls them all from Berlin. The four French companies are: the Société Française d'Industrie Chimique, the Société des Etablissements Joudrain, the Société du Fondoir Parisien, and the Société des Anciens Etablissements Verdier-Dufour. The first-mentioned concern was started in the year 1911 to take over the works of Tancrede and Collette, the former founded in 1836, the latter in 1864, respectively, at Aubervilliers and at Nevers, capital 2,000,000 francs, the former receiving in shares and debentures 2,800,000 francs, the latter 1,350,000 francs. The management rests with the Scheidemandel Company. The Société des Anciens Etablissements, Joudrain, was formed in a similar way, in 1912, with a share capital of 1,500,000 francs, the vendors receiving 1,875,000 francs—in shares for 1,000,000 francs, and in bills of exchange for 875,000 francs, payable in 10 yearly instalments. In both cases the vendors undertook not to start any competition for 15 years. The Scheidemandel Company has secured the majority of the shares; both concerns are located in the same building in Paris and managed according to Scheidemandel principles.

The three French concerns in question were also in a good commercial position before joining, or, rather, being absorbed by the Scheidemandel Company, with agencies both at home and abroad, the Joudrain, for instance, in Brussels, Barcelona and New York, and it has, of course, been greatly to the advantage of the Scheidemandel Company to secure the entire control of all this. These affairs satisfactorily settled, the Scheidemandel Company at once started a new large scheme, which almost amounts to a monopoly of the handling of all the refuse and offals in Paris and its environs. By the aid of chemistry and a developed technique hardly any part of a carcase now goes to waste. The treatment of the offals has, in Germany, reached the highest degree of perfection, and the municipalities of the large cities, Berlin, Cologne, Dresden, Munich, Hamburg, have constructed factories with the most

SHIPPING SHED AT GOOLE; LANCASHIRE AND YORKSHIRE RAILWAY.

MR. D. C. RATTRAY, CHIEF CIVIL ENGINEER, AND MR. G. HUGHES, CHIEF MECHANICAL ENGINEER, TO THE COMPANY.

Fig. 1. SECTION A.B. (Fig. 3.)

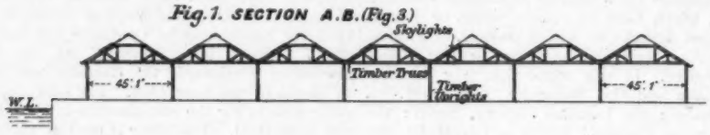


Fig. 2 SECTION C.D. (Fig. 3)

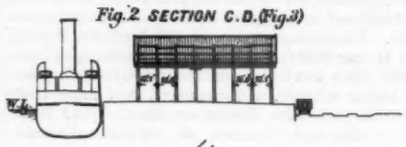


Fig. 3.

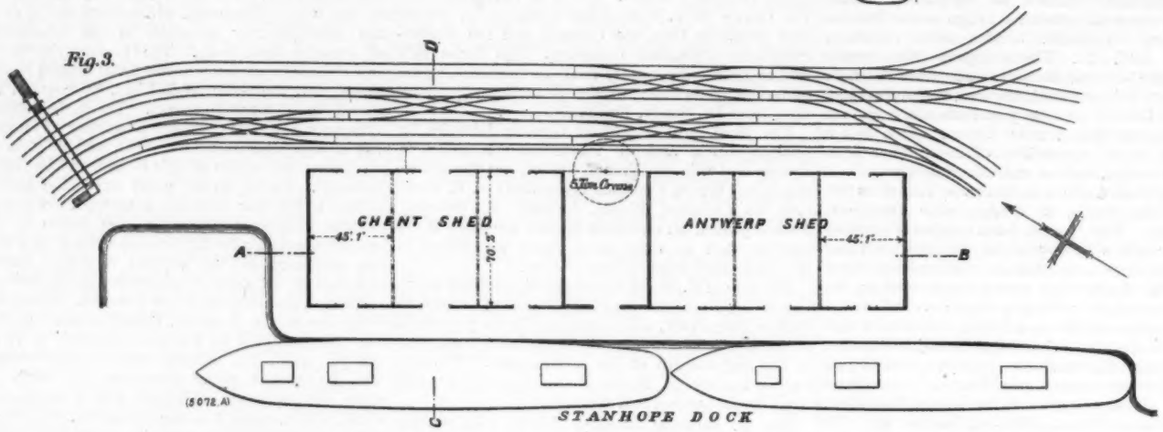


Fig. 4. SECTION E. F. (Fig. 6.)

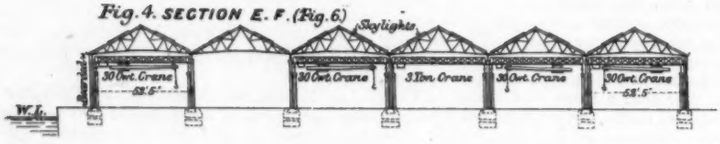


Fig. 5. SECTION G.H. (Fig. 6.)

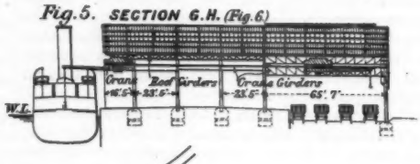
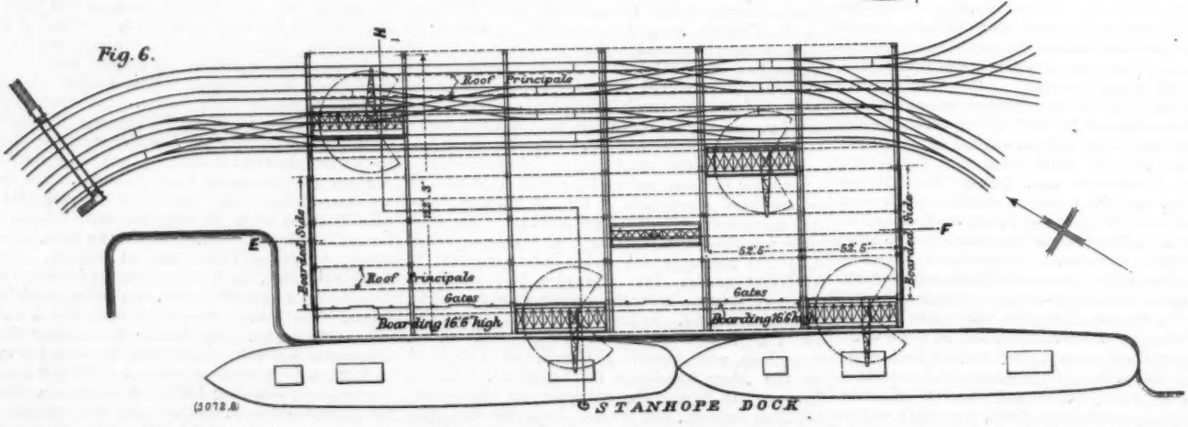


Fig. 6.



approved technical installations, where the most scrupulous hygienic precautions are observed.

In France this industry still left much to be desired, which was openly admitted by French authorities as recently as 1911. At that time there were three factories in the vicinity of Paris which handled the offals from the slaughterhouses, when the Scheidemandel Company took up the matter and within a year succeeded in forming a combine of these factories and put the whole industry on an entirely new footing. The Union de la Boucherie was bought for 1,000,000 francs, the exploitation of the bones was taken in hand by one concern and that of the blood by another. Extension followed upon extension, and new factories were erected. As a result the Scheidemandel Company, within a very short time, by purchases and agreements, literally secured the monopoly of the glue, bone fat, bone meal and manure industry of the Seine Department.

UNITED STATES: EDUCATION AND THE WAR.—We are informed that the fifth Summer School of Scientific Management, usually held in the Gilbreth Laboratories, at Providence, R.I., will be postponed a year, at least, on account of the war.

LANCASHIRE AND YORKSHIRE RAILWAY SHIPPING SHED AT GOOLE.

WE have in previous articles referred to the urgent importance of the railway companies reconstructing their goods stations and shipping sheds, in order to economise man-power, and we are able, by the permission of Sir John A. F. Aspinall, general manager of the Lancashire and Yorkshire Railway, to illustrate one more admirable example of how this can be achieved. The docks at Goole are the property of the Aire and Calder Navigation, and were primarily intended as a terminus to the canals of that company, through which they have connection with the whole of the canal system of the United Kingdom. The Lancashire and Yorkshire Railway Company have long leases of certain portions of the property, on which they have erected their own buildings and plant. The illustrations on this page show sections and plan of the old Ghent and Antwerp shed at Goole Docks, and a corresponding shed of the same size, just built on the same site with special regard to economy in man-power and the rapidity of unloading and loading ships engaged in the continental trade. In such trade the difficulties of the shipowner are due probably to the variety of and large number of small consignments, and also to the wide field throughout which imports have to be distributed and from which exports are collected. No doubt these difficulties explain why in the old structure little or no effort was made for handling the consignments by cranes within the sheds. It was found sufficient to utilise the ship's winches and derricks to lift the consignments from the hold and deposit them on the wharf, whence they were taken by hand trucks to the shed or to a wagon on the siding, where the wagon was filled up, as far as possible, for one destination. There was one crane in the old shed, centrally situated over the siding, so that the heavy loads could be lifted into the truck. As the crane was stationary, a great amount of shunting had to be done to bring the wagon being filled for a given destination to the crane to take the heavy load. Indeed, an enormous amount of shunting was necessary to bring the wagons from the three outer lines of rails on to the siding immediately adjoining the loading platform.

All these objections have been overcome by the admirable design of the new shed and of the crane equipment. The length of the new shed is

SHIPPING SHED AT GOOLE; LANCASHIRE AND YORKSHIRE RAILWAY.

MR. D. C. RATTRAY, CHIEF CIVIL ENGINEER, AND MR. G. HUGHES, CHIEF MECHANICAL ENGINEER, TO THE COMPANY.

Fig. 7. ENLARGED SECTION G H. (OMITTING CRANES).

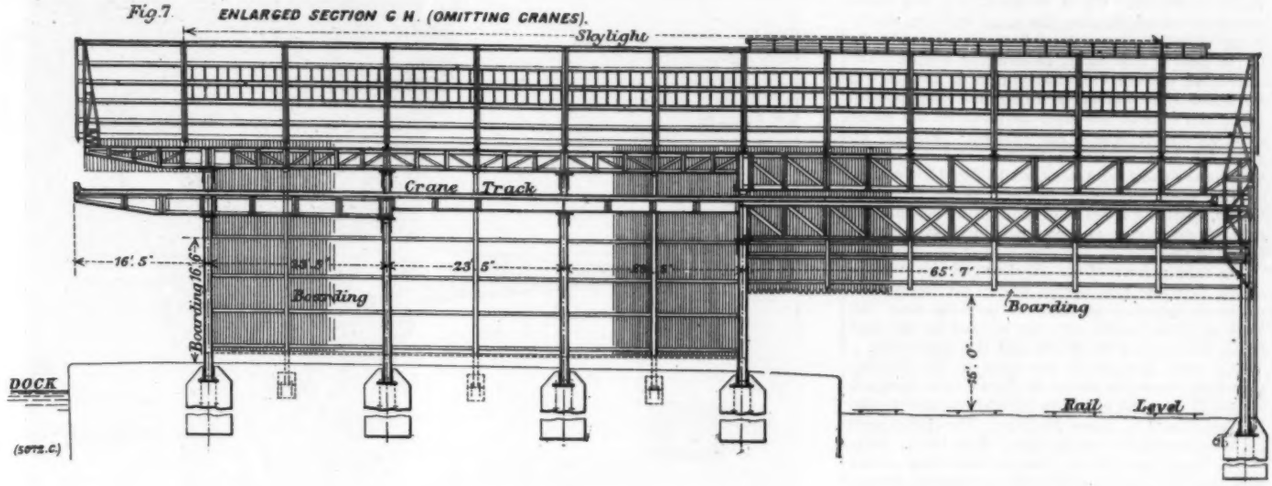
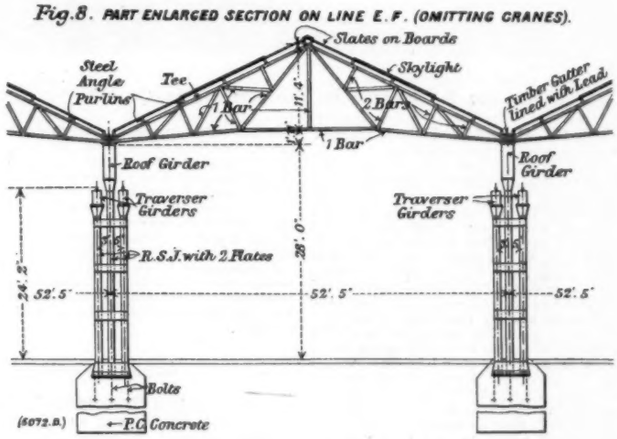


Fig. 8. PART ENLARGED SECTION ON LINE E. F. (OMITTING CRANES).



practically the same as that of the old shed, but instead of there being seven bays of 45 ft. 1 in. span there are six bays of 52 ft. 5 in. span. The reason why this alteration was made was to ensure that the hatchways of the holds of the typical Lancashire and Yorkshire continental steamer would be exactly opposite a bay, as shown in Fig. 6; so that an overhead crane travelling in the bays could be utilised for lifting consignments from the hold of the ship. For this purpose the cranes are of a special type, the crab having an underhung slewing horizontal jib, and as the crane track extends right to the edge of the quay this swinging jib can command the centre of the hatchway. Another important development is the extension of the roofing of the shed and the overhead crane tracks across the four lines of rails on the landward side of the shed, as shown in Figs. 5 and 6. The crane can pick up a consignment from the hold, travel down the bay, and drop the consignment in a truck on any of the four tracks. Thus there is the minimum amount of shunting, no manual handling of goods on the way from the hold to the truck, and consequently a great saving in labour and great expedition in discharge. The same applies to loading. The conditions at present are not normal, owing to the war, but there is every probability that the effect of the change will be to save quite 30 per cent. of the time in loading and discharging steamers. In this way the Lancashire and Yorkshire Railway will once more influence greatly the prosperity of the port of Goole.

Goole already owes much to the Lancashire and Yorkshire Railway. It is one of the furthest inland ports on the East Coast, being situated on the River Ouse, about 45 miles from the sea. It was not until 1904 that the Lancashire and Yorkshire Company obtained Parliamentary powers to establish a service of steamers between the ports of Goole and Hull and several of the principal continental ports. The company, as a result of their enterprise, are now the largest steamship owners amongst the British railways. At the commencement of the war the company owned 25 steamers, with an average carrying capacity of 1,000 tons, the tendency of the company being to standardise the types and to make the sheds conform as far as possible to the dimensions of the ship. These steamers sail regularly between the ports of Goole and Amsterdam, Antwerp, Copenhagen, Delfziel, Dunkirk, Ghent, Hamburg and Rotterdam. A large part of the trade of the port of Goole is in the export of coal, and special facilities are provided to this end, there being five coal appliances for discharging railway wagons into the holds of ships and five for lifting up the sections of canal barges for discharging their coal contents into ships. These wagon hoists range up to 50 tons capacity, and vary considerably in design. Those for the canal barges, which belong to the Aire and Calder Navigation, are of considerable lifting power, suitable for raising the standard sections of canal-boat "trains." The Lancashire and Yorkshire Company themselves have put up a 25-ton crane for bunkering steamers and loading coal, and they have also a 20-ton and a 30-ton hydraulic hoist for the same purpose. There are in all seven docks, the total length of quayage being between 16,000 ft. and 17,000 ft. The latest and largest of these, namely, the West Dock, has a length of 1,050 ft. and a width of 290 ft., the depth of high water at spring tide being, as in all cases, 20 ft. The draught of the vessels frequenting the port is not more than 18½ ft. The principal entrance locks are 460 ft. in length and 22 ft. in width, and 17 ships have been "penned" in and 17 out in one tide. The prosperity of the port, as we have said, is largely due to the enterprise of the Lancashire and Yorkshire Railway. They have in the port itself about 25 miles of railway sidings, and have done everything to develop the trade. The imports to and exports from Goole in 1901 equalled 11,500,000*l.* In 1905, when the Lancashire and Yorkshire Company took over the steamship lines already named, there was an advance on the figures of the previous year of over 2,250,000*l.*, the total becoming nearly 16,500,000*l.* By 1910 the total was over 18,750,000*l.*, and in the years immediately preceding the outbreak of war the total had advanced to 20,500,000*l.*

There can be no doubt that the new Ghent and Antwerp shed will tend further to develop the traffic in the port, particularly as it is indicative of the active policy of the Lancashire and Yorkshire Railway Company. The new shed, which was designed by Mr. D. C. Rattray, the chief engineer of the Lancashire and Yorkshire Railway, is illustrated in detail by the sectional drawings on the present page. The old shed was a timber structure, consisting, as we have already said, of seven spans, each of 45 ft. 1 in., with only one 5-ton stationary crane. The new shed consists of six bays, each of 52 ft. 5 in. The old building was 70 ft. 2 in. in width, whereas the new building, extending practically to the edge of the quay and over the four lines of railway track, is 152 ft. 3 in. in width. Fig. 7 is a longitudinal section through one of the bays, with a 30-cwt. crane, while Fig. 8 is a cross-section showing the columns, crane track, roof girders and principals. The roof principals, which are placed 11 ft. 8½ in. apart, are of steel, of the Belgian truss type, consisting of a T-back, with struts and ties of flat bars. They are carried on steel open-web girders, as shown in Fig. 7, supported by steel stanchions placed 23 ft. 5 in. apart, in the enclosed portion of the shed, and built up of rolled joists and plates. Similar stanchions on each side of, and braced to, the roof stanchions support solid web girders carrying the travelling cranes, as shown in Fig. 8. The roof girders and crane-track girders are carried over the dock quay, as shown in Fig. 7, in the form of cantilevers, 16 ft. 5 in. long. The construction over the four lines of track is also shown in Fig. 7. The principals in this case are carried by steel open-webbed girders, with an open span of 65 ft. 7 in., the crane girders over the sidings being also of the open-webbed type. The purlins are of

steel angles, and the roof is partly slated and partly glazed, about one-third of the area being glazed.

Perspective views are given in Figs. 10 and 11, on Plate VI, further to illustrate the constructional steelwork. Fig. 9, annexed, is a view taken along the wharf, showing the crane with the underhung slewing jib, with a load as it would be in the case of loading or discharging a ship. The cantilever girders are clearly shown, and it will be noted that timber boarding has been put up along the side of the shed adjacent to the wharf as a protection against the weather. Fig. 10, on Plate VI, is a view showing the extension of the shed across the four tracks, while Fig. 11 is a view of the same extension looking along the four tracks, showing a crane depositing a consignment of goods on a truck on the track furthest removed from the shed.

The taking down of the old shed and the erection of the new one was carried out in six operations, so as to interfere as little as possible with the working of the traffic, only two bays of the old shed being interfered with at one and the same time.

The most important accessory is the electric travelling cranes, as shown on Figs. 4 to 6, designed by Mr. G. Hughes, chief mechanical engineer to the Lancashire and Yorkshire Railway. The cranes were made by Messrs. Craven Brothers, of Reddish. Four of the bays have 30-cwt. electric travelling cranes with underhung slewing jib, while one bay has a 3-ton crane of similar construction. They are arranged, as we have said, to suit the holds of the standard ships, and can pick up goods from wagons placed in any of the four sidings, traverse the shed, and drop their load into the ship's hold without manual handling. The cranes are illustrated in detail on Plates VII to IX, so fully that little description is necessary. Figs. 12 to 14, on Plate VII, show the general arrangement. The design includes all the best modern features in overhead cranes; strength and speed, combined with simplicity and ease of upkeep, have been aimed at. The girders and longitudinal travelling gear, shown in Figs. 15 to 20 on the same Plate, present no unusual features. The travelling centre and its jib, illustrated by Figs. 21 to 27, on Plate VIII, are, however, of special interest in respect of the large radius—28 ft.—combined with the small depth taken up by that portion of the crane projecting below the girders, this distance being only 4 ft. 9 in. The jib revolves on a cast steel centre pillar (Figs. 22 to 25) suspended from the centre of the cross-travelling truck; the slewing and lifting motors, the controllers and their resistances, with the driver's seat, all being fixed upon and forming part of the underhung jib, Figs. 21 and 26. The crab is shown in detail in Figs. 28 to 32 on the same Plate, while on Plate IX are details of the cage and slewing brake (Figs. 33 to 35), and of the controller with its current collectors (Fig. 36).

Normally the jib of the crane is in its highest position, as shown in the general arrangement, Fig. 12, but provision is made so that the end of the jib may be depressed to enable it to project under the longitudinal girders into a neighbouring bay, and thus transport goods from one bay into another. To enable this to be done the jib is pivoted and the back end is moved up and down by means of a powerful hand-operated screw gear, the wheel for which is fixed close to and in front of the crane driver (see Figs. 21, 33 and 35).

The speeds of the various motions are as follow :—

Lifting	150 ft. per min.
Slewing	2 revs. per min.
Cross-travel	100 ft. per min.
Long-travel	360 " "

The current used is tri-phase, 400 volts, 50 cycles. The motor equipment is as follows :—

	h.p.	r.p.m.
Lifting motors	25	600
Long-travel motors	15	750
Cross-travel motors	10	730
Slewing motor	3	750

The controllers and resistances are of the tramway type; these, together with the collecting rings fixed at the lower end of the jib centre pillar for the lifting and slewing motors and illustrated in Fig. 36, present no unusual features. The capacity of the cranes is 30 cwt., and the unloaded weight of each appliance is 21 tons 12 cwt.

SLEWING JIB CRANE AT SHIPPING SHED, GOOLE.

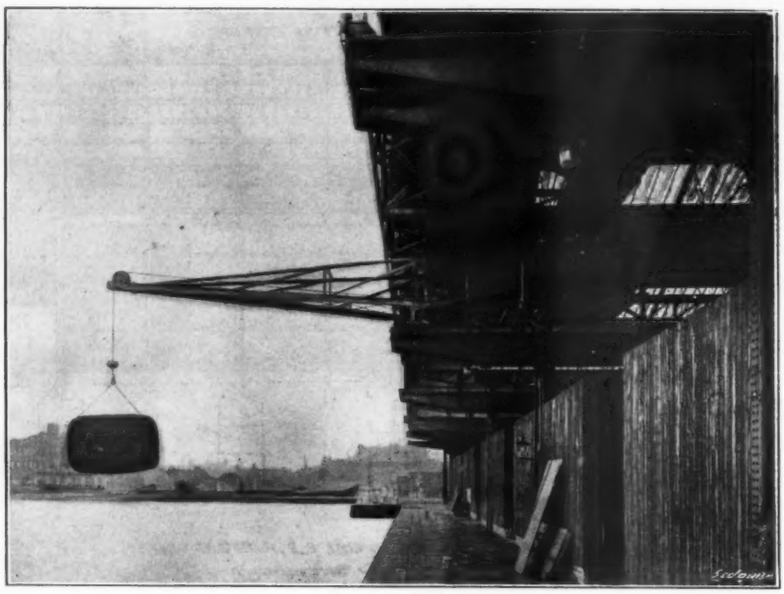


FIG. 9. SLEWING JIB PROJECTING OVER QUAY.

THE FUTURE OF BRITISH INDUSTRIES.

TO THE EDITOR OF ENGINEERING.

SIR,—I hope you can find space in your pages for ventilating the above subject, which is of vital importance to this country, during, and even more so after, the cessation of the present hostilities. After the war this country has to start a new war of commercial and industrial competition against countries at present her enemies, her Allies and, as a matter of fact, the whole world. If she has to regain the lost ground and to keep her position and the trades partly regained during the war, we have to put forward other methods than have been adopted generally and by the heads of industry and the Government in particular before the war. The present general feeling of unrest in the industrial world only goes to show what is expected to follow, viz., a severe clashing between the forces of labour and capital; in other words, the employees and the employer. This antagonism between two who should work hand in hand in a united effort to increase output and efficiency of this country, cannot carry on any longer by the antiquated, pre-war methods of strikes, concessions of increased wages and limitations of output. All this would be less acute had we not to compete with the outside world, but only by full efforts on the part of both employer and employees can we hope to come out top dog and beat our foreign competitors in the world's output. We have got the brains, even if not always the technical and scientific training, on the latter of which has been laid far too much stress in the past. The British grit has shown itself often enough in the individual person when placed in foreign lands on his own resources, but the system of our organised industries is at fault at the root of the matter. So long as the employers look upon their business solely as a concern to fill their pockets or pay their shareholders a large dividend without looking further, so long will British industries work under this cloud and lose their grip gradually of the world's markets. It is only by a complete reversal of these methods that salvation for this country and its industries can be hoped for. The payment of minimum wages, however high, on the part of the employer, and the restriction of output by the employees, will never bring it to us. The employers generally should be made to believe and to see that *co-operation* with their workers only can bring them lasting, increased output and profits, as well as the best that is in their workmen. The employer should be made to see that to achieve this end he must take a wider view of commercial economy and give the man he employs a vital interest in the work in hand and the business in general. He should give him a fair share as a result of his labour and forethought, by granting him a proportionate share in the profits at the end of the financial year. He should also pay him accordingly for any invention he may be able to devise, without the present debarring restrictions as to whether the invention is made in the working time or is acquired during the process of such work or is of the class of work he is now engaged on. In other words, the employer must make his employees feel that it is to *their own* as well as their employer's interest to turn out as much and as good work as possible; a thing very few men nowadays think about, and with reason. It is well known that there are already, even in this country, a few firms who have incorporated in the conduct of their business the above ideas, as at Port Sunlight, Bournville and others, and the growth of these firms should be a striking proof that the above ideas are not those of a mere dreamer and theorist. The idea of profit-sharing and the encouraging of inventions is a question to be grappled with seriously in the near future, and if properly handled it will hit and put down several of the pre-war industrial evils, as strikes, aggressions of trade unions, restrictions of output and the utilisation of original British inventions by more far-seeing foreign manufacturers.

I hope some of the many employers amongst your readers will take note of this letter and begin to think more about the truth contained in this idea, which has been ventilated before in many papers and industrial societies.

Yours truly,
"COURT."

THE BRITISH THERMAL UNIT.

TO THE EDITOR OF ENGINEERING.

SIR,—"Therm." to denote B.Th.U. (see letter on page 48 of your last issue), is not anything new, and its use seems to have given way to "B.Th.U." Therm is the term used throughout a treatise on "Heat and the Steam Engine," by I. Warren, M.A., Dublin, 1895.

On page 54, we read :—

"1 Therm = heat required to raise 1 lb. water through 1 deg. C.—the English thermal unit."

"1 calorie = heat required to raise 1 kg. water through 1 deg. C."

"1 calorie = 2.2 therms."

C. R. K.

GOVERNMENT EMPLOYMENT.

TO THE EDITOR OF ENGINEERING.

SIR,—I should like to draw attention through the medium of your columns to a personal experience of the utility of the Labour Exchanges as a medium of finding employment. On July 2 I registered as a tool designer and production engineer, giving full particulars of experience and salary required, but up to the time of writing I have not received a reply of any description. That men with the above qualifications are urgently required cannot be confuted, as witness the advertisement pages of your paper. No doubt many of your readers have had a similar experience, and it must be apparent to them and the great majority of engineers in general that such a state of affairs does not reflect credit on the organising ability of the Ministry of Munitions, who claim to be so anxious to use our services. Is it yet too late for the above-mentioned body to institute a Central Bureau, supervised by one who is conversant with the technicalities of modern engineering, to deal with such cases?

T. G. F.

"ON THE DIFFERENCES IN EFFECT OF TWIN SCREWS WHEN TURNING 'INWARD' OR 'OUTWARD.'"

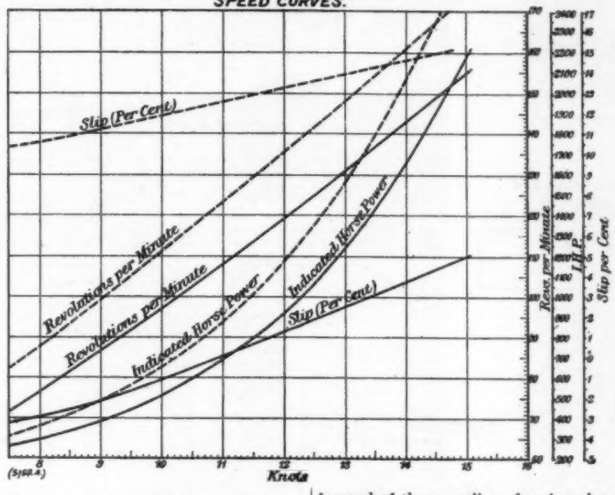
TO THE EDITOR OF ENGINEERING.

SIR,—In connection with the article by Mr. Holst which appeared in your issue of May 4 last, on page 415, it perhaps will be of interest to your readers to be

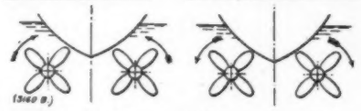
informed of the results of some trials carried out by my firm (Messrs. Burmeister and Wain) some years ago, and from which it will appear that, under certain circumstances, even a considerable gain can be expected in propulsive efficiency with the same propellers turning "inward" instead of "outward."

The ship in question was a twin-screw railway ferry—

T.S. RAILWAY STEAM-FERRY "CHRISTIAN IX" SPEED CURVES.



CURVES FULL LINES CURVES DOTTED LINES



Length on water-line ..	290 ft.	290 ft.
Breadth (mean)	39 ft. 4 in.	39 ft. 3½ in.
Draught, fore	10 ft. 10 in.	10 ft. 9½ in.
Draught, aft.	13 ft. 3 in.	13 ft. 1½ in.
Displacement	2156 tons	2135 tons
⊠ Area	420 sq. ft.	418 sq. ft.
Block, coefficient	0.60	0.60
⊠ Coefficient	0.967	0.97
Prismatic coefficient ..	0.620	0.616
Diameter of propellers ..	9 ft. 6 in.	9 ft. 6 in.
Pitch of Propellers ..	10 ft. 4 in.	10 ft. 4 in.
Expanded surface.. ..	3.55 sq. ft.	35.5 sq. ft.
Immersion	2 ft. 8½ in.	2 ft. 7 in.

built by my firm for the Danish Government—of the following dimensions :—

Length between perpendiculars	290 ft.
Breadth (rule)	39 ft. 6 in. on 12 ft. 6 in. mean draught
Depth, moulded	18 ft. 8¾ in.
Keel	12 in.

The sides were sloped to an angle of about 0.20 deg., the rule breadth being the mean of breadth on water-line and breadth on base-line.

As due regard had to be paid to the conditions in the existing ferry harbours, the draught and width over tips of propeller blades was limited, thus giving a very small diameter of propeller. Also it was decided to run the propellers turning "inward," this giving a more suitable arrangement in the engine-room, as also reducing the engine-room staff, and the lines and bosses were designed in accordance with this decision.

The trials were carried out in the following manner :—

The ship was docked, cleaned on the bottom and painted, and then put on trial in "Oresund," with the propellers in the original position ; that is, the propellers turning "inward," or the port propeller being right-hand and the starboard left-hand turning. A series of runs on the measured mile was made at different speeds, so as to be able to plot exact speed and revolution curves. Directly following this trial the ship was docked and the propellers changed from port to starboard and *vice versa*, and the ship again put on trial, repeating the runs on the mile.

The results will be clearly understood from the accompanying curves, which show by full lines the results from the first trials with "inward" turning propellers and by dotted lines the results from the second trial with "outward" turning propellers.

It will be noted that—on all speeds—a constant gain of about 0.8 knots is effected by turning the propellers "inward" instead of "outward," putting the same indicated horse-power through them, although this may be done by considerably less revolutions. On the other hand, the difference in revolutions on the same speed is remarkable, as also that this difference is not proportional, but is increased by increasing speed. It may be stated that both trials were undertaken under as even conditions as is ever possible, and, besides, they are checked by several other trials with the same ship and a sister ship built some years later.

In my opinion the results of these trials tend to show that, as stated by Mr. Luke, it is possible to obtain the same propulsive effect and hull efficiency with propellers turning "inward" or "outward," only the bosses must be designed in accordance with the direction of rotation. In this case the bosses were built as fins running right aft to the propeller struts and inclined 70 deg. to the horizontal. The deadwood aft was cut up some 40 ft. forward of the propellers, forming almost a motor-boat stern and leaving the propellers working 9½ in. clear of the ship's sides.

I am, yours truly,
Copenhagen, June 28, 1917. IVAR KNUDSEN.

THE HARD CASE OF INVENTORS OF NON-WAR INVENTIONS.

TO THE EDITOR OF ENGINEERING.

SIR,—As a British subject who has taken out a large number of patents, mainly for one important invention, both in Great Britain, the Colonies and foreign countries, I venture to draw attention to the unenviable position in which a British inventor is placed at the present time.

Should his invention be of such a nature that it is not of special use for the war he is probably unable to do anything with it. He is obliged, however, to take out his patents as usual; the specification giving the particulars of his invention has to be completed and published here at the required time, and if he does not apply for his patents abroad before then he is precluded from taking them out at all in most countries. Hence, if his invention is a big one, comprising a number of sets of patents, he finds his expenses in holding his invention are growing, while he is unable to get any financial return for his work and the capital he has expended. The inventor has to pay the Government renewal fees on his patents just the same as if he were making a handsome profit out of his invention, and in some countries the charges have been actually higher since the war. Thus each year the war drags on the inventor finds himself in a worse position. No matter how useful and novel his invention may be, or how sound his patents, unless he can afford (and few individuals can) to keep on paying out without any return, the time must come when he has one of two alternatives, either to sacrifice his invention and let the work—perhaps of years—go, or possibly to meet ruin for himself and his family. This notwithstanding that his invention may be good and that he would have done well with it in peace time. The invention may be such that it would form an industry of itself and by proper development with British capital would give to British industry the ascendancy in a particular business. By the Defence of the Realm Act it has become impossible to raise capital publicly, and also, owing to the requirements of the Ministry of Munitions, impossible to get engineering work done. But all the time, be it noted, the Government is extracting the normal royalties from the unfortunate inventor who keeps his inventions together. Is this injustice to continue ?

Surely the war should have taught the country, if anything ever will, that invention should be encouraged, that it is necessary for progress, and that an inventor who brings out something useful, novel and ingenious is a benefactor to his country. Recently inquiries have been made about certain patent rights from Germany and Austria, showing that these countries are active, but negotiations could not be entertained during the war. It is recognised that when the war is over we shall have to meet keen industrial competition from the United States and Germany, countries which before the war were ahead of us in their application of science to the requirements of everyday life. In these countries invention has been encouraged and has stimulated their progress. Before the war it was proposed in Germany to give still further encouragement by a national institute for the furtherance of invention, with laboratories where new ideas would be worked out with expert assistance, and a financial bank to finance those that were of value, a certain percentage being deducted from the profits for the assistance given. If our country is to hold its own it is absolutely essential that it should adopt a different attitude towards invention to that which it has done in the past. I urge, therefore, that something substantial be done, and a commencement be made now before peace comes, or it will be too late. The following suggest themselves as directions in which assistance might be rendered.

1. Genuine inventors might be helped at the present time where the war has placed unprecedented difficulties in their way. The Government should require only a nominal fee on those patents which have not or cannot be worked during the war.

2. A scheme should be drawn up now generally to assist and encourage invention after the war.

As regards (1) it should be possible to obtain an extension of patent rights without any expensive procedure. The time of extension should be adequate—in the case of patents taken out before the war and as yet unworked or unremunerative the extension should be equivalent to the whole period lost from the granting of the patent to the end of the war. The Treasury should give facilities for the raising of capital for promising inventions which have been held up, and the Ministry of Munitions as far as possible should allow the construction of models and manufacture.

As regards (2), the furtherance of invention after the war, I would suggest the advisability of greatly reducing renewal taxes or charging no tax after the issue of the patent, as in the United States of America. The Government should not wish to make money out of British inventors, as invention is to the industrial interest of the country, also the Government should carry through negotiations for the institution of a more uniform system of international patent law. The extension of patent time should be obtainable without expensive procedure, patents should be considered on their merits. Those which have required years of work and much outlay on experiment and the loss of much patient time before there is any return should be dealt with differently from small patents, mere improvements in some small device.

In addition, something might be done to form a permanent institute to further invention, as previously referred to.

I have the honour to be,
Yours faithfully,
H. K. HARRIS, M.A.

96, Victoria-street, S.W., July 11, 1917.

ASCERTAINING THE CENTRE OF GRAVITY OF A PLANE SURFACE.

TO THE EDITOR OF ENGINEERING.

SIR,—In order to estimate the volume of a solid which may be described by the revolution of a longitudinal section around a central axis, it is usual to multiply the sectional area of one side by the circumference of a circle having a diameter equal to the distance between the centres of gravity of two opposite longitudinal sections.

The following is a more rapid method of locating the centre of gravity than any I have seen published, including the plumb-line method.

Trace the section and cut it out of the heaviest tracing-paper available. Guess the position of C.G. and fold the tracing once, with the fold passing through this point. Open the paper to, say, about 90 deg., keeping the two sides as flat as possible, and balance it, on a pin placed under the fold, so that the fold is horizontal. Press gently over the pin till its point penetrates the paper, flatten the latter out and again fold it, through this mark, in a direction at right angles to the first. Balance as before, when the pin will mark the centre of gravity.

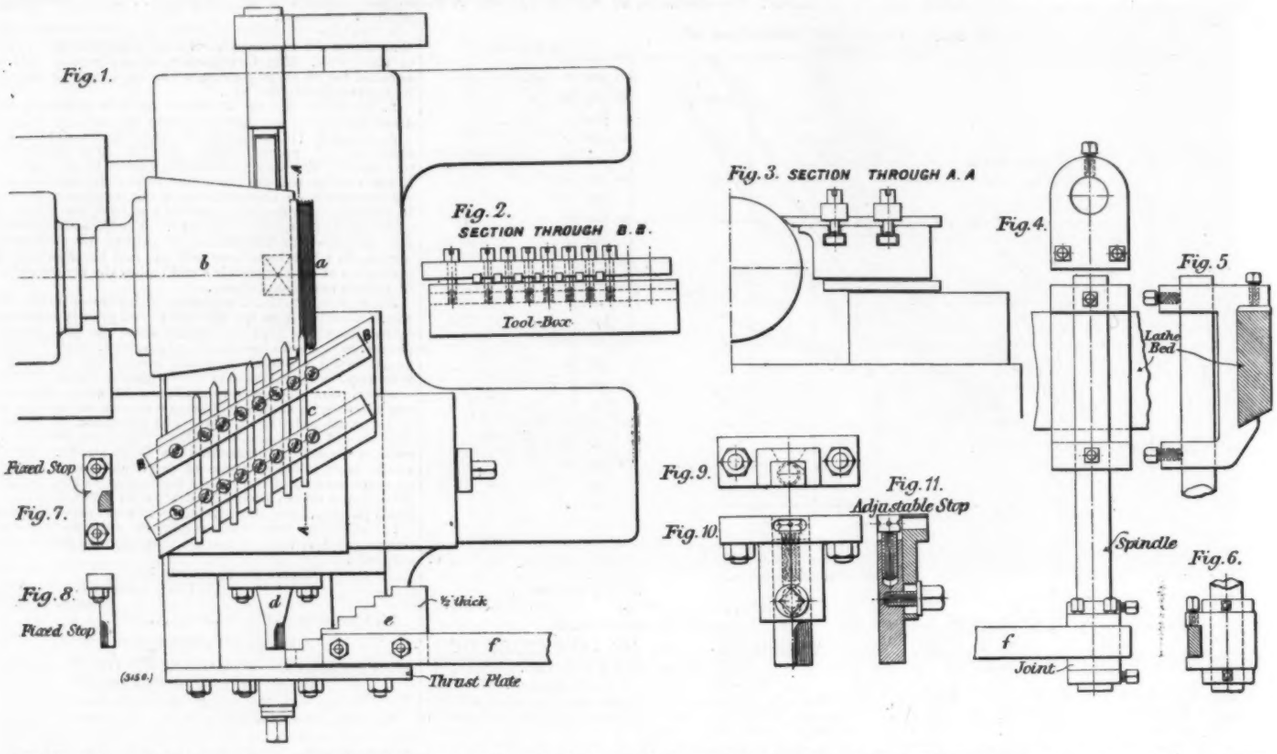
In the above operations the easiest way of securing horizontality is to hold the paper between the eye and the bar on a window-sash. Of course heavier paper is better, but for the object in view and with sections of moderate size, stout tracing-paper answers the purpose if care be taken.

Yours faithfully,
C. H. WINGFIELD.

ALLOYS TO REPLACE PLATINUM.—The steady rise in the price of platinum was very striking even before the war. In the United States the ounce troy was estimated at about 6 dols. in 1874, at 20 dols. in 1901, at 45 dols. in 1914, and at 110 dols. in 1917. During the war the platinum production of Russia has decreased from 300,000 oz. in 1912 to 12,400 oz. in 1915; the United States produced, in 1915, 742 oz. of platinum, imported 65,000 oz., recovered as much from gold and copper, and recovered a further 40,000 oz. from scrap (jewellery and dental work); the platinum production of Colombia, next in importance to Russia, was 18,000 oz., in 1915; New South Wales and Tasmania together hardly produce more platinum than the United States. Looking for possible substitutes for platinum, F. A. Fahrenwald (*Journal of Industrial and Engineering Chemistry*, June, 1917) arrives at the conclusion that none of the platinum and other elements can replace platinum in its manifold valuable properties. But he has obtained good results with his rhotanium alloys, which seem to consist of gold and palladium, and, further, of silver and rhodium. These alloys are made in various grades. Rhotanium, he states, does not resist hot concentrated nitric acid, but is equal to platinum as regards corrosion in other acids, bases, salts, &c., and as cathode, though not as anode. It can be rolled and shaped, and being stronger than platinum, the rhotanium parts need only be half so heavy. Rhotanium is not more oxidised and less volatile than platinum below 1,300 deg. C., and very serviceable for the dentist and jeweller. The gold percentage of different grades of rhotanium is said to vary between 60 and 90.

THE CARVER SCREW-CUTTING DEVICE FOR REPETITION WORK.

MESSRS. W. D. WANSBROUGH, SKELSEY AND GUNTHER, ENGINEERS, BIRMINGHAM.



WE illustrate on this page a device due to Mr. J. D. Carver, Walsall, for repetition screw-cutting on an ordinary screw-cutting lathe. There are, for example, numerous cases in which screw plugs of considerable diameter, but with but a short length of thread, are needed in quantity, and it is for work of this character that the arrangement was originally devised. When working on plugs of 26-ton steel, $5\frac{3}{4}$ in. in diameter and screwed for a length of $\frac{9}{16}$ in. with 14 threads per inch, finished to a shoulder, an output of 30 per hour has been obtained; whilst $2\frac{1}{2}$-in. plugs are screwed for a distance of $\frac{1}{2}$ in. in $10\frac{1}{2}$ seconds. In Fig. 1 the device is shown in operation on work of the above character. The plug *a* is held in a suitable chuck *b*, and operated on in succession by the seven tools shown in place at *c*. These tools are clamped under two bars set diagonally as shown and slotted, so as to space the bars evenly, as best seen in Fig. 2. The whole set are mounted on a casting, which is clamped to the compound rest of the lathe, as indicated in Fig. 3.

The thread is finished at one traverse of the saddle. At the outset, with tool No. 1 in action, the stop *d* bolted to the cross-slide abuts on the highest step of the plate *e*. As this first tool comes up the shoulder of the plug being screwed, the stop *d* comes on to the second step of the plate *e*. This motion carries the first tool clear of the work and the second comes into action. As it finishes, the third tool begins to cut, and so on, until the final cut by the seventh and finishing tool. In the illustration this is shown just in the act of completing the thread up to the shoulder. This done, the step *d* moves down to the thrust-plate, and the saddle is then run back to operate on a fresh plug. In this return motion of the saddle the stop *d*, which is bevelled on one side, as indicated, slips under the bevelled edge of the plate *e*, raising the latter. To permit of this the plate *e* is carried on an arm *f* which swivels on a rod clamped to the lathe bed, as indicated in Figs. 4, 5 and 6. The stop *d* may be either fixed, as represented in Figs. 7 and 8, or adjustable, as in Figs. 9 to 11.

The first three of the seven tools rough cut the thread. Tools Nos. 4 and 5 cut each side respectively. No. 6 cuts to the full depth, whilst No. 7, which may be of the chaser type, finishes the thread to the exact form. The average length of time for which the tools will run without regrinding is 30 hours when cutting mild steel. "Stellite" for the first two tools and "Victory" for the remaining tools of the set are stated to be brands that have been found to work well.

The device has, we are informed, been adopted by one of the principal electrical manufacturing firms, who are using the system for threading cast-iron commutator hubs. The screwed portion of these is 6 in. in diameter by $\frac{3}{4}$ in., and there are 12 threads per inch. The time allowed for the threading operation prior to the introduction of the Carver system was 15 minutes for each. This has now been reduced to under 2 minutes, and it is claimed that the work is better done.

Messrs. W. D. Wansbrough, Skelsey and Gunther, of 73 and 74, Exchange Buildings, Birmingham, control the use of the apparatus in this country, and issue licences for its adoption.

GERMAN TRADE METHODS.—The Paris *Revue Générale de l'Electricité* reproduces an advertisement which has appeared in the Berlin *Electrotechnische Zeitschrift* of April 19, of which the following is a translation:—"Switzerland.—A Swiss electricity firm, owning a large capital and having first-class connections for export, will undertake after the war the export and also the (*Veredlung*) improvement, perfecting of German electrotechnical products. Excellent references will be sent on application. Apply through the intermediary of Alfred Reichardt, Hamburg 36, Jungfernstieg 8." It is difficult to see where the Swiss *Veredlung* of German electrical manufactures comes in and to what extent it can be applied. Following upon the above advertisement, foreign markets are sure to look askance at any offers coming from Switzerland for all classes of machinery and fittings.

SHIPBUILDING IN SHANGHAI.—According to *The London and China Telegraph* a very successful launch took place from the Pootung yard of the Shanghai Dock and Engineering Company, Limited, of the single-screw steamer Jan, for the Norwegian owners, Messrs. Torp and Weise, Bergen, which is being built under the supervision of their captain-superintendent, Captain Lars Jahn, and Captain J. H. P. Parker, surveyor to Det Norske Veritas. She is a sister ship of the Valuta, recently launched by the company, and is 254 ft. 6 in. long, by 37 ft. moulded breadth and 17 ft. moulded depth; like the Valuta she is to Det Norske Veritas' highest class and has double bottom for water ballast and all modern appliances for handling cargo. All the machinery for the Jan and the Valuta, each consisting of one large set of triple-expansion surface-condensing engines of about 1,200 i.h.p., with two large multitubular cylindrical boilers and usual auxiliaries, including steam steering gear, steam windlass, steam winches, evaporator, &c., has been made in the company's own workshops. The company is now hastening the construction of two larger vessels, also for Norwegian owners.

THE UNITED STATES MOTOR SHIP "MAUMEE."—The largest Diesel-engined motor ship so far built in the United States, says *Marine Engineering*, New York, is the twin-screw naval collier Maumee, of 14,500 tons displacement, propelled by two single-acting, two-cycle Diesel engines of 2,600 shaft horse-power each. Each set of engines has six cylinders, 25.2 in. in diameter for a 37.37-in. stroke. At a normal speed of 130 revolutions the engines are designed to give the ship a speed of 14 knots. Since she was completed, last December, the Maumee has been in active service for five months, and during that time has made 18,000 miles. The only defect that has developed has been the cracking of some of the cylinder jackets, which is apparently due to lack of sufficient clearance between working liners and jackets. It is thought that additional clearance can readily be allowed, and when this is done the engines will be ready for any service. The consumption is about 0.5 lb. of oil per shaft horse-power for all purposes.

MOLYBDENITE AND NICKEL ORE IN CALIFORNIA.—Molybdenite (molybdenum sulphide) has recently been discovered in San Diego County, California. Visiting the district, F. C. Calkins (Bulletin 640—D of the United States Geological Survey) found the ore occurrences near Ramona, situated nearly 40 miles from San Diego in one of the basin-like valleys of the country. The predominant rock is a biotite granite, greenish-grey in colour, which is cut by many dikes of aplite. This latter term indicates a granite, whitish-grey unless red with iron, which is harder and weathers less than the darker granite, so that the aplite dikes stand out like walls. The molybdenite is found together with reddish quartz in the aplite, but only sparely. It forms crystals up to $\frac{1}{4}$ in. in diameter, which are lead-grey in colour and soft like graphite; in some places it has been transformed into yellow-green iron molybdate. There is no geological survey of the district so far, and the importance of the occurrence cannot be estimated yet. The same county also contains, near Julian, some 20 miles further north-east, a nickel ore, interesting particularly because nickel ores are not mined at present within the United States. The Julian district lies more than 4,000 ft. above sea-level and is very rugged. Igneous rocks again predominate, an amphibole-bearing olivine gabbro and a dark grey mica schist being common. In the Friday mine is found a pyrrhotite, together with pyrite, chalcopyrite and an iron-nickel sulphide not yet sufficiently identified, silvery white in appearance—the other sulphides are more yellow—probably $Ni_3Fe_2S_3$. As this nickel ore generally goes together with copper sulphide, its isolation may not be easy. Calkins considers that it must have originated somewhat like the Sudbury nickel ores; gold, silver and also arsenic seem to be absent. Prospecting, except by diamond drill, would be difficult. On dumps the ore rapidly oxidises and the nickel sulphate is washed away by the rain; dumps should hence be protected.

BURFORD-CLEVELAND TRACTOR AND "ONCE-OVER" TILLER.

MESSRS. H. G. BURFORD AND CO., LIMITED, ENGINEERS, LONDON.

FIG. 1. THE BURFORD-CLEVELAND TRACTOR, WITH TWO-FURROW PLOUGH.

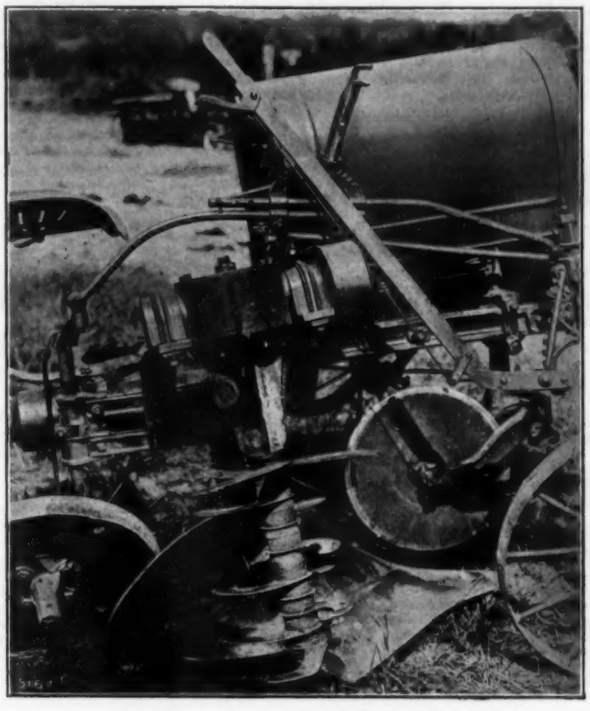


FIG. 2. THE "ONCE-OVER" TILLER.

LAST Tuesday there was a demonstration of a new American caterpillar tractor, and of a "tiller," at Mr. Edge's Blackbrook Farm, Ditchling, Sussex. The trial took place under ideal conditions for mechanical traction. The land was level, and its surface was perfectly dry. The soil beneath the surface was just damp, and of a friable nature. It is classed as Sussex weald clay, but to the depth to which a plough penetrates it suggested to an engineer the idea of a coarse, lumpy moulder's sand. A handful tightly grasped in the fingers retained its form when laid down carefully, but easily fell to pieces if it were disturbed. Part of the land was pasture three years old, and part was stubble. The former, of course, was strongly held together by the roots of the grass, while the latter broke up more easily, but the cut still turned over quite regularly.

Subject to this explanation the trial was perfectly successful. The tractor drew a two-furrow Ransome-Oliver plough, and evidently could have managed a three-furrow plough. The depth of cut was 6 in., and the width of each furrow 9 in. The plough was hand-guided, and hence the speed was limited to the capability of the man to follow it, but with a plough on which a man could ride, or which could be manipulated by the attendant on the tractor, the speed might have exceeded the three miles an hour or so which was attained. On the pasture and on the stubble the tractor ran on the undisturbed ground and made practically no impression, as might be expected from its weight and dimensions. As shown by our illustrations (Fig. 1) above and on page 66 the weight, which is about 25 cwt., is well distributed. The two travelling tracks have an aggregate surface of 600 sq. in. in contact with the soil, each caterpillar chain being 6 in. wide. The pressure on the ground is therefore less than 7 cwt. per square foot, or about the same as that imposed on the land by a man standing on one foot. It is clear that while in one sense the condition of the land was very favourable to the tractor, from another point of view it was quite adverse, as it afforded the machine no opportunity of exhibiting its capabilities. What the buyer wants to know is how such a machine will behave on wet and steep slippery clay. It is a matter of experience that a heavy-wheeled tractor will often dig itself into such ground up to its axles, and make its owner long for his horses, which, at any rate, always managed to get through somehow. The caterpillar may be relied upon not to slip on any land that is fit to be ploughed at all. When, on Tuesday, the machine was set to draw a cultivator over land which had been ploughed and broken up to seed-bed condition by the "tiller," it did so with perfect ease and without slipping, although the ground was so soft that one's boots sank into it as if it had been sun-and-wind-dried sand on a crowded shore. In watching the tractor being manipulated one recalled the tanks as seen on the films. It went from the stubble over the gap left by the ploughshare on to the soft earth with perfect unconcern, pitching and rolling over the irregularities of the ground, and turning through the soft earth as easily as on the pasture. One quite felt that it did not have a chance to show what it really could do.

The construction of the tractor is well shown on the views (Fig. 1, above, and Fig. 4, page 66). It comprises a four-cylinder motor, with cylinders 3¼ in. by 5½ in., driving through a plate clutch on to a differential through bevel gears, with a reverse motion (Fig. 4). From the differential the power is transmitted to each of the hind wheels (Fig. 3) of the tractor by short jackshafts, on each of which is fixed a pinion gearing with teeth cut on a rim inside the wheel. The wheels have solid centres and contain oil, so that the gearing is constantly lubricated. The reduction is 9 to 1. The two main wheels on one side of the tractor, together with the three bearing wheels between them, and the jockey wheel above (Fig. 4) are carried on a frame pivoted at one end on the main axle, and suspended at the front from a cross spring. The whole forms a three-point suspension, and allows the two caterpillar chains to adjust themselves to the variations in the ground. The pivots of the small bearing wheels are all lubricated with pressure grease cups, so that there is a constant flow of grease outwards against the entry of sand and mud.

At each side of the differential there is a brake drum, surrounded by a strap tightened by the hand wheel in front of the driver. When either strap is tightened the corresponding wheel is slowed and the opposite wheel accelerated, with the result that the tractor is turned, the minimum radius being 6 ft. The links of the caterpillar chain are cast, and are connected together by hardened hollow steel pins, which contain a store of lubricant which can be forced out by a screw at the end. Starting is effected by petrol, and the running maintained on paraffin. The main dimensions are: height, 4 ft. 4 in.; width, 4 ft. 2 in.; length, 8 ft.; track centres, 3 ft. 2 in.; and clearance, 12 in. The draw-bar pull is 2,200 lb. and the horse-power 20.

A tractor can be used for many purposes on a farm. It will draw a plough (Figs. 1 and 3), a cultivator, a harrow, a roller, a drill, a harvester (Fig. 6), a self-binder, or a wagon, and under some conditions two or three at the same time. It will also drive stationary machinery in the farmyard or the stackyard. The one in question is designed for the farmer of moderate means. It will not compete with steam-ploughing tackle, nor even with powerful tractors designed for six furrow ploughs. But it will do many things for which larger machines are commercially unfitted, and it will often be successful when the large machine will become hopelessly bogged. In the nature of things a caterpillar must be subject to great wear and tear. No care in design can secure permanence from a chain which is constantly enveloped in mud or dust, or from small bearing wheel centres run under like conditions. However, that is one of the disabilities that has to be faced, and it is well repaid if the machine will draw ploughs in all conditions of the soil in which ploughing is desirable. If farmers would bestow one-fourth the care on their machines which they give to their horses the task of the engineer would be greatly simplified. After his day's work the horse is fed, watered, groomed and bedded, while the machine is often pushed into an outhouse, or left in the open with little or no attention, and surprise is expressed when it breaks down. A little more care would immensely reduce the bill for repairs.

The tractors which were shown on Tuesday have only recently arrived from America. They are stated to embody many years of experience of Mr. H. Rollin White, one of the founders of the White Truck Company. They are named the Burford-Cleveland tractors, and are being introduced here by Messrs. H. G. Burford and Co., Limited, of 11, Waterloo-place, London, S.W.

Together with the tractor there was shown the "Once-over tiller," which is to be seen in Figs. 2 and 5. This is a plough on which is mounted a petrol motor driving a vertical shaft fitted with revolving screw-like blades. The plough is not self-moving, but has to be drawn by horses, or by a tractor, and the sole purpose of the motor is to drive the screw shaft through a chain and bevel gears. The blades revolve within a short distance of the mould board of the plough,

and as the cut is turned they break it into fragments and distribute it over a width of 3 ft. to 4 ft., in pieces not exceeding the size of a walnut. It is claimed that this machine will prepare a seed-bed at one operation, and dispense with cultivating and harrowing. It was quite successful on Tuesday, but the conditions were very favourable. The machine itself is mechanically in a much earlier stage of development than the tractor, but from all accounts seems to comply with the conditions found in the United States. It is constructed by the Scientific Farming Machine Company, of Minneapolis.

THE BRITISH ASSOCIATION—ERRATUM.—A few lines were unfortunately left out from our paragraph on the British Association on page 38 of last week's issue. From the eighth line this paragraph should read: We sincerely hope that nothing will interfere with the further arrangements made which were submitted to the meeting of the General Committee on Friday, July 6. In the ordinary course of events Sir Arthur Evans . . .

ALUMINIUM IN CANADA.—The Canadian Customs returns for the year 1916 give the exports of aluminium in bars and blocks as 92,212 tons; the value of manufactured aluminium articles exported from the country during the year was estimated at 26,000 dols. These figures do not represent the full production of aluminium in the works of the Northern Aluminium Company at Shawinigan Falls, since a great deal of aluminium is used in Canada itself.

"ENGINEERING" ON GERMANY AND ITS INDUSTRY.—Lieutenant Richard Smedberg, the editor of the "Way and Water Construction" portion of the Swedish *Teknisk Tidskrift*, published in the issue of August 18, 1915, of that periodical an article on "The Influence of the War on Technical Journals," in which, among other things, he found fault with the attitude of British technical papers towards Germany and her industry in general, and complained in particular about the alleged "anonymous outbursts against Germany" by ENGINEERING during the first months of the war. For some occult reason, in its issue of May 19 last, the *Zeitschrift des Vereins deutscher Ingenieure* published *in extenso* a translation of this article, which has now been republished, also *in extenso*, by the new editor of *Stahl und Eisen* in its issue of June 14 last, and will no doubt make the tour round the German press. Lieutenant Smedberg's outburst surprised us considerably, as we felt quite innocent of anything exceeding the bounds of sane and legitimate criticism, and on reference to our issue of the date he quotes (March 12, 1915) he will find neither therein, nor, as a matter of fact, in any other issue of our journal, a single article to which he could fairly take exception. To the editors of the *Zeitschrift* and of *Stahl und Eisen*, on the other hand, we would recommend reference to page 308 of the 1915 volume of the *Zeitschrift*, as quoted by its editor, when they will find that the *Teknisk Tidskrift* was mistaken in attributing to us the articles in question.

CAST-IRON.—In our issue of May 18, 1917, we referred to the investigation by Mr. J. E. Johnson of foundry iron, which certainly has not been studied in anything like the way that steel has been studied. The statement made by different authorities on the influence of the ordinary constituents of iron on the properties of cast-iron are contradictory. Some systematic experiments, conducted at Aachen by Professor Wüst and his students, were described by A. Stadeler in *Stahl und Eisen* of September 28 and October 26, of 1916, on pages 933 to 939 and 1,034 to 1,039 of that volume. The investigators started from a Swedish charcoal iron and a Swedish iron for horseshoe nails, which they mixed so as to vary the total carbon percentage between 2 and 4, and added to the resulting product ferro-manganese, ferro-silicon and ferro-phosphorus. Thus they obtained cast-iron containing, in addition to varying percentages of carbon, only one or more of the other constituents in different proportions, silicon up to 2.56 per cent., manganese up to 2.46 per cent., phosphorus up to 1 per cent.; the sulphur content was 0.014 per cent. Rods, 30 mm. in diameter and 70 mm. long, were cast and tested as they were for flexibility—as to which the different specimens did not differ much—and bending strength; for the other tests (tensile strength, impact tests, Brinell hardness, metallographical examination) specimens were prepared. The mechanical properties were found to depend mainly on the quantity and character of the graphite; these properties are themselves influenced by the cooling, of course, which is the second essential factor. Small quantities of Mn (up to 0.37 per cent.) favoured the formation of graphite in the grey iron; a further increase of Mn had no influence. A pig iron rich in phosphorus could be improved by 1 per cent. of Mn, contrary to prevalent views. Bending and tensile strength decreased as the graphite percentage rose, and in this respect the graphite might be replaced by silicon, because the presence of silicon favours the segregation of coarse graphite. The presence of Mn (1 per cent.) and also of P (up to 0.3 per cent.) improved the strength; as to flexibility, high graphite percentage and phosphorus (up to 0.3 per cent.) were favourable, silicon and manganese injurious. The impact strength was unfavourably affected by increase in Si, Mn, and especially in P. The hardness diminished with increasing graphite, and rose with increasing Mn and P. When the mechanical tests gave irregular results the metallographical examination revealed differences in texture. All the specimens of good mechanical properties contained a large portion of their graphite as temper carbon.

DEALINGS IN PIG-IRON.

WE have received the following official announcement:—

With reference to the Order made by the Minister of Munitions on July 7, 1916, applying Regulation 30A of the Defence of the Realm Regulations to war material consisting of certain classes and descriptions of metallurgical metal, coke, pig-iron and steel, and to the general permit for dealing in such war material issued by the Minister of Munitions on November 1, 1916, the Minister of Munitions hereby gives notice:

1. That the said general permit is modified by the insertion in the schedule thereto of the following prices for the articles hereunder specified in addition to or, where such articles are already specified in such schedule, in substitution for the prices contained in such schedule.

Maximum Prices of Hematite Pig-Iron—Malleable—(per ton net f.o.t. makers' works).

Refined.	£	s.	d.
Refined cupola-cast	8	0	0
Refined cupola-cast to guaranteed analysis	8	5	0
Cast Direct from Blast-Furnaces.			
Small pig-iron—all grades	7	10	0
Medium pig-iron, white to grey mottled	7	5	0
Medium pig-iron, all other qualities	6	17	6
Large pig-iron, all grades	6	17	6

All the above prices include agent's commission or merchant's profit, which is not to exceed 5*s.* per ton. Applications for licences to sell special grades of extra quality at special prices will be separately considered by the Director of Steel Production.

Cleveland Pig-Iron (per ton net f.o.t. makers' works).

	£	s.	d.
Basic	4	17	5
South Staffordshire, Shropshire and Worcestershire Pig-Iron.	£	s.	d.
Basic	4	17	6

All the above additions to the schedule of the general permit will take effect from the date of this notice, and none of such additions shall be deemed to prejudice or interfere with the carrying out of any contract in writing for sale or purchase of the above-mentioned war material entered into prior to such date at prices lawful at the date of such contract.

Cleveland Pig-Iron (Substituted Price per ton net f.o.t. makers' works).

	£	s.	d.
No. 1	4	16	6
Other grades	4	12	6
South Staffordshire, Shropshire and Worcestershire Pig-Iron.	£	s.	d.
"Part mine" forge	5	0	0
"Part mine" foundry	5	2	6

The above substituted prices shall take effect from April 2, 1917.

2. That in further modification of the said general permit, in all districts an extra charge of 1*s.* per ton may be charged over the fixed maximum price for basic pig-iron cast in chills.

TECHNICAL COMMITTEE OF THE MOTOR INDUSTRIES.—The third meeting of the Technical Committee of the Motor Industries was held at the offices of the Institution of Automobile Engineers on Tuesday, June 19, 1917, when many important questions were discussed. Mr. A. A. Remington (Wolseley Motors, Limited) was elected chairman of the committee for the year; Lieut.-Colonel R. K. Bagnall-Wild being elected vice-chairman. Among other matters upon which a definite conclusion was reached was the adoption of the suggestion of Mr. W. H. Paull that the time is now ripe for a serious effort to be made to introduce an international standard of wheel and tyre rims for solid rubber tyres. It is suggested that France, United States of America, Italy and Russia would be willing to co-operate with Great Britain in this direction. This view has been forwarded to the Engineering Standards Committee. Steps are being taken to collect data on several subjects of proposed research, and in this connection an important proposal has been made to the committee that a bureau of technology should be established where all technical information with regard to various branches of the motor industry may be obtained, and from which would be issued a periodic *précis* of up-to-date information relating to the latest advances of science and the possibilities of their application in the realm of automobilism. Such a scheme might be of immense service to the engineers of the automobile industry, but it cannot go through without the financial support of the firms, although it is quite likely that the Government would, through the Department of Industrial Research, make a substantial contribution to income. As yet, the subject has not received any detailed consideration, but it is one on which those interested are invited to express their views. Another matter of great importance that has been brought before the committee is the proposal to form a central organisation for the better co-ordination of engineering training, and in this matter the committee is already giving all the support that has been asked of it at the present juncture. The committee is now represented on all the Engineering Standards Committee Automobile Sub-Committees, and steps have been taken to render every assistance in this direction. Steps have also been taken to ensure the proper representation of motor industries on the Civil Aerial Transport Committee, as there is no doubt that mechanical transport must play a very important part in any such scheme.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The position in this area continues to be overclouded with the prospective new regulations. These have produced a good deal of uncertainty, and there is a feeling that owing to the great amounts which will have to be provided for industrial purposes in the South Yorkshire district there will be difficulty in getting a satisfactory working arrangement. Time alone can prove the truth or otherwise of this, but nevertheless the scheme is being severely, if not bitterly, criticised, and has had some effect in reducing the amount of business on the open market. Collieries seem to be concentrating so much upon contract needs that there is little or no coal to be had outside these well-defined limits, particularly of the hard steam variety. Works have placed big contracts, and are trying to get the maximum percentages as a precautionary measure for winter emergencies, and this leaves the position of the smaller buyers in a far from ideal state. Smaller sorts share the general activity, with slacks in great demand from the Lancashire as well as the Yorkshire mill districts. The export trade is not so large in volume for these grades as during the earlier part of the year, but this is the only direction in which the collieries have been able to ease off at all. In other ways this relief has been more than counterbalanced, and there are many arrears on the order books. Cokes are firmly held at full rates. Householders are being provided with regular, if not too substantial supplies. Quotations:—Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire best brights, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire house coal, 17*s.* to 18*s.*; best large nuts, 16*s.* 6*d.* to 17*s.* 6*d.*; small nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; and smalls, 7*s.* 6*d.* to 8*s.* 6*d.* per ton at the pit.

Iron and Steel.—The output of steel is gradually increasing. There seems to be good progress made in all directions to expand the production, and up to date there is every promise that the prevailing shortage, which undoubtedly does exist for certain work, will be made good at the earliest opportunity. An augury of this is to be found in the energy with which works extensions are being proceeded with at this late hour in the war. The need, however, is urgent, especially for marine work. It is worthy of note that the restrictions on the export of steel are being tightened, and shipments are becoming smaller as a consequence. Some of the Sheffield houses with business interests and works abroad are now unable to send any quality of tool steel to their foreign works. At one time it was permissible to send carbon tool steel in small quantities, though high-speed steel was banned, but now the regulations appear to have a more sweeping effect, and the home trade is becoming more and more the Alpha and Omega of steel production and consumption. Steel makers are in much happier position with regard to hematites than a few weeks ago. Arrivals are regular and fairly substantial. This improvement is not confined to the special sorts, but to all grades. With Derbyshire furnaces turning their attention more and more to basic quality of pig-iron, there is a greater difficulty in getting full tonnage of foundry and forge brands, for scarcely any Lincolnshire pig-iron is coming into this district, though an increase is expected when the furnace alterations are completed. This state of affairs makes the Derbyshire output most eagerly sought, and it is easy to realise that if prices were not regulated there would begin another of those sensational upward tendencies which caused so much dislocation and difficulty in the days before the advent of the Ministry of Munitions control. All the same, makers contend that they are entitled to a further 5*s.* on present quotations, and in many cases would-be consumers would willingly give this for prompt supplies. War requirements are still increasing. The needs of the allied armies for tools and implements of all descriptions are really amazing in the light of what was originally intended by the contracts placed in the first two years, and these alone represent a great call for steel. Workshops are stated to have orders in hand for this class of work which will last them for twelve months ahead. Manchester Tramway Committee have accepted local tenders for steel points and crossings, malleable cast-iron, light iron and wire, files, tool steel, steel springs, copper cable, &c. Railway work is coming forward in fairly substantial quantities. The cutlery, plate and silver trades are busily engaged on export orders, and have not the material nor the labour to cater fully for demands nearer home. The general state of the overseas trade is good when all circumstances are taken into account.

TUBING FOR ELECTRIC WIRES—ERRATUM.—In our issue of July 13, on page 38, in a paragraph detailing a method of making tubing for electric wires from strips of muslin saturated with plaster of Paris, the word "heat" was printed as "beat." The mandrel coated with paraffin wax is heated to release the tube, not beaten.

CONCRETE RAILWAY SLEEPERS.—In the current issue of *Concrete and Constructional Engineering*, published at 4, Catherine-street, Aldwych, W.C., there is an article on concrete railway sleepers. There are short notices of all the trials of such sleepers made by the leading railways in all parts of the world, together with many photographs and drawings of the sleepers used. There are also particulars of many distinctive types of sleepers, setting forth their dimensions, and the devices for supporting the chairs or flat-footed rails. In view of the growing scarcity of timber in many parts of the world the article is of great interest to railwaymen.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—With the shutting-down of all industrial concerns in the Glasgow area for the annual Fair Holidays the steelmaking industry is practically at a standstill this week, with the solitary exception of some urgent Government contracts which must be pushed through without delay. In most cases work will be resumed on Monday of next week, although a few days' longer respite has been granted where extensive and elaborate repair to machinery has been found necessary. To make allowance for the stoppage, and keep the output at the required level, a very strenuous effort was put forth during the days preceding the holiday in all Government controlled establishments, the result of which was eminently satisfactory. The entire industry is dominated by the circumstances of the war, and, as has been the case for some time past, the whole production is used, directly or indirectly, for war purposes, leaving little or nothing for private home consumption, and even less for export, despite the efforts which have been made to maintain the greatest possible output. From the point of view of the mercantile trader or consumer the outlook is none too brilliant, as stocks are now perilously low, and since the entry of America into the war that source of supply can no longer be relied upon, the increasing war demands making vast inroads upon all the available stocks in hand. No change has taken place in local rates.

Malleable Iron Trade.—The position of the malleable iron trade remained unchanged when active operations ceased on Thursday or Friday for ten days or so. Every mill has been running constantly for months past, and the general activity has been unparalleled, the heavy demands made by Government having considerably tightened up the sources of supply. Although the output has continued on an exceptionally large scale, it has not been possible to divert any of this into other channels, with the result that ordinary mercantile business, both home and export, is practically at a standstill. Prices remain unaltered.

Scotch Pig-Iron Trade.—In consideration of the heavy demand for all classes of Scotch pig-iron, the blast-furnaces have not been damped down, so that it is expected that quite a considerable amount of stock may be in readiness for the steel and iron works when they resume operations after the holidays. Up till the last working day there were urgent requests from the local steel works for large quantities of hematite, and from the iron works for forge and foundry qualities, but these demands will now be in abeyance for a few days. While home rates are unchanged, those for export are firm, although little overseas trade is being done in the meantime.

VALIDITY OF OHM'S LAW FOR HIGH CURRENT DENSITIES.—It has often been suggested that Ohm's law cannot hold for currents of very high density. J. J. Thomson calculated in 1908, in his "Corpuscular Theory of Matter," that Ohm's law should fail, and the current should not longer be proportional to the potential difference and field intensity, but become proportional to the square root, for gradients of 10^6 volts per centimetre. Those values seem to lie outside the range of experimental possibility. Experimenting with fine silver wires (0.03 mm. diameter), which he cooled by placing them in rapidly flowing water, Lecher had found, in 1907, that the law did still appear to hold for current densities of 1.4×10^4 amperes per square millimetre; but he could not altogether avoid heating of the wire. In the *Physikalische Zeitschrift* of February 15, 1917, H. Rausch von Traubenberg describes an arrangement after Bjerknes, by means of which he confirmed the validity of the law for densities of 10.5×10^4 amperes per square millimetre and gradients of 550 volts per centimetre. He used an oscillatory circuit provided with spark gaps on either side of the condenser, and shunted the wire under test across the one gap. His wires had a length of 15 cm. and a diameter of 0.1 cm., and consisted of konstantan and kruppin; in the latter material he could produce potential gradients of 1,500 volts per centimetre.

THE GERMAN CHEMICAL AND EXPLOSIVE INDUSTRY.—An understanding has been arrived at between the works of the big chemical industry, the so-called "aniline" concern, and the "explosives group," and indirectly also with the "powder group," which latter works in connection with the explosives group. The new arrangement may be looked upon as settled, even if all the documents have not yet been actually signed. The aniline works, from the stoppage of their export trade and the dearth of raw materials, have been compelled to curtail their regular peace manufacture and instead go in for the production of materials used in the explosives industry and of actual explosives. It is this increased production of explosives, &c., which has enabled Germany to carry on the war as she has, and has even resulted in a surplus, and this, again, is due more especially to the vast increase in the atmospheric nitrogen industry. As long as the war, with its immense munition requirements, goes on, this increased production will not be attended by any drawbacks. The new arrangement is only intended to come into operation after the war. Its purpose is to secure and fix the production of the respective groups, which at present is very much alike, and to lay down mutual limitations of the manufacture. The individual groups will maintain their complete independence and entire freedom within the allotted domain, and will consequently also have free hands altogether as regards their price policy.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is a quiet, but steady and firm feeling in Cleveland pig-iron. Initiative is so closely circumscribed by official regulations, that a new development cannot be expected. Home transactions are now on a very limited scale, consumers here being fully bought for July, whilst very small supplies are going to customers north of the Tweed owing to the Scottish holidays. There are, however, already tentative inquiries out for next month, and a renewal of brisk buying on home account is confidently anticipated on the issue of August allocations. Large inquiries from abroad are reported, and there is rather more foreign business passing, due to the better tonnage outlook. For home consumption No. 3 Cleveland, No. 4 foundry and No. 4 forge are all quoted 92*s.* 6*d.*, and No. 1 is 96*s.* 6*d.*; whilst for shipment to France and Italy No. 3 is 102*s.* 6*d.*, No. 4 foundry 101*s.* 6*d.*, No. 4 forge 100*s.* 6*d.*, and No. 1 107*s.* 6*d.* The stock of Cleveland pig-iron in the public warrant stores still stands at 1,137 tons, all of which is No. 3 quality.

Hematite Iron.—There is practically no new feature in the East Coast hematite branch. Official organisation continues to assure adequate supplies to home users, and to leave some surplus iron available for shipment. A few sales to customers reachable by rail are reported from time to time, but obstacles to new foreign business are still difficult to overcome, and few sales abroad are being put through. Some improvement, however, is reported in shipments to our Allies against old contracts, and with the expectation of more tonnage coming forward heavier loadings, especially for Italy, are looked for. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use, 137*s.* 6*d.* for shipment to France, and 142*s.* 6*d.* for export to Italy.

Furnaces in Operation.—The recent blowing-out of a hematite blast-furnace for repairs reduces the number of furnaces in operation in the North-East district to 77, of which 35 are making Cleveland pig-iron, 28 are producing hematite, and 14 are manufacturing basic, spiegel and other special irons. Messrs. Bolckow, Vaughan and Co., Limited, are ready to blow in an additional furnace at their Clay-lane works, and have asked for an immediate supply of 2,000 tons of Cleveland ironstone extra per week.

Coke.—Values of coke are well upheld, notwithstanding plentiful supply. Descriptions needed for the local blast-furnaces are in very good request, and continue to command full prices, average qualities realising the fixed maximum of 28*s.* at the ovens, and low phosphorus sorts selling at the limitation figure of 30*s.* 6*d.* at the ovens.

Manufactured Iron and Steel.—Little new is ascertainable concerning the various branches of the finished iron and steel industries. To cope with continued heavy Government requirements and large shipyard needs, manufacturers are kept working at heavy pressure, and surplus material available for sale in the way of ordinary commercial business is very limited indeed. Quotations, all round, are very strong. To home customers, common iron bars are 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; double best bars, 14*l.* 10*s.*; treble best bars, 14*l.* 17*s.* 6*d.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 18*l.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 20*l.* and upward; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel strip, 17*l.*; steel hoops, 17*l.* 10*s.*; heavy steel rails, 10*l.* 17*s.* 6*d.*; packing iron and steel (parallel), 13*l.*; and packing iron and steel (tapered), 15*l.* 5*s.*

IONISATION OF THE TERRESTRIAL ATMOSPHERE BY HALLEY'S COMET, 1910.—People were rather disappointed in May, 1910, to have no direct evidence of the fact that the earth had really passed through the tail of Halley's Comet as had been predicted. Arrangements were made at the time at various observatories to determine whether the ionisation of the air was in any way affected by the comet. Examining the general and special meteorological records from 17 stations (in Japan, Russia, Hungary, Germany, Italy, France, Tunis, Iceland, Toronto), A. Wigand (*Physikalische Zeitschrift*, January 1, 1917) finds, in 11 out of the 17 cases, evidence of an increase in the ionisation, to a very unequal degree, however. He concludes that the increased ionisation was not due to any radiation from the comet's nucleus or tail, but must be ascribed to something radioactive in our upper atmosphere.

INVESTIGATION OF SPIEGELEISEN.—Some particulars of an investigation of the spiegeleisen of a blast-furnace of the Siegen district in Westphalia were given by H. Thaler in the *Berg und Hüttenmännische Rundschau*, 1916, pages 61 and 69. The term is applied to a shiny white, very hard and brittle iron of high carbon percentage, containing manganese, but otherwise fairly pure, which is produced under certain conditions at high furnace temperatures. The manganese content of the slag varied between 9 per cent. and 10 per cent. The ratio of silica to lime in the slag should be 1.7 to 2; when the silica percentage rises, more manganese passes into the slag. The presence of alumina in the slag is favourable for the manganese retention, because in such cases the silica percentage is generally lower. The manganese losses decrease with increasing manganese percentage in the iron. A slow passage of the charge through the furnace is desirable. With inferior grades of spiegeleisen the manganese losses are small; they are higher for higher grades, and amount to 7 per cent. or 8 per cent. in the case of a spiegeleisen of 20 per cent.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Business on the coal market this week has been almost entirely at a standstill. One great difficulty is the delay in the settlement of the classification lists under the new schedule of minimum prices. The patent fuel, coke, and pitwood markets are also idle, and the weakness of pitwood and coke is as pronounced as it has been at any time during the past few weeks.

Newport.—There is no change to report in the market for Newport coals. It is probable that later on an improved demand for the more bituminous of the Monmouthshire coals will arise from the conditions of the Controller's new redistribution scheme; but the full force of that new demand will not be felt until later in the year, and even then its practical value will depend on the rationing house coal method of distribution, which it is understood the Controller intends to announce during the course of the next few weeks. The quantity of coal being shipped at Newport is below the average, and pits have again been reported idle.

Coal Controller's Scheme.—The career of the Coal Controller's scheme fixing a graded schedule of minimum prices for coals exported to foreign destinations seems to be proving as difficult as that of practically all the other artificial measures which have been taken during the past two years to regulate prices and direction. It was only when an attempt was made to give practical effect to the Controller's scheme that its inherent faults were ascertained. The committee appointed by the Monmouthshire and South Wales Coalowners' Association to classify and adapt coals produced in South Wales to the grades formulated by the Controller soon discovered that in its original form the scheme was unworkable, and on their own initiative they ignored one of the most important of the grades specified in the schedule, namely, that of best bunker smalls, and lumped the small coal outputs of upwards of forty collieries under the one heading of ordinary bunkers. Many other serious objections have been urged against both the original schedule and the committee's classifications, and as a possible way out of these difficulties the committee have written to the Controller asking his sanction for the addition of seven or eight new grades. These relate to large, through and small coals. The reply of the Controller has not yet been received, but in any case that reply, if favourable, cannot be put into effect till all the collieries affected by the new grades have been communicated with. Under these circumstances the new classification list is hardly likely to be promulgated before, at the earliest, the end of next week.

YOKOHAMA HARBOUR.—It is stated, says *The London and China Telegraph*, that following the completion of the new pier in Yokohama, the Department of Finance will turn its attention to the dredging of the harbour. According to the official scheme, 494,000 tsubo will be dredged to a depth of 35 ft., 353,000 tsubo to 30 ft., and 200,000 tsubo to 24 ft. The work will extend over a period of 10 years. (1 tsubo = 3.95 sq. yards.)

HIGHER IRON PRICES IN GERMANY.—In harmony with the price movements for other iron products the quotations for hoop iron have been raised, and at about the same rate as the increase in the prices of other B products for the third quarter of the present year. For deliveries in July the hoop-iron prices have been raised 30 marks per ton, and for deliveries in August and September 40 marks, in anticipation of higher prices for fuel.

ORE CONCENTRATION BY FLOTATION.—Since we published an article on flotation in our issue of August 25, 1916, the legal aspect of the flotation practice has undergone an important change in the United States. The Minerals Separation, Limited, brought an action for infringement of patent against J. M. Hyde, who had installed the first large American flotation plant in the works of the Butte Superior Mining Company. The plaintiffs claimed that the use of less than 1 per cent. of oil, reckoned on the dry weight of the ore, was their own patented speciality, whilst the defendants argued that the diminution of the amount of oil was merely the result of the practical development of the process natural to all processes, in which some expensive material was added for some particular purpose. Though some experimenters had recommended a good supply of oil, they had all attempted to keep the oil consumption down. The United States Supreme Court, in December last, upheld the claim of Minerals, Limited, that the use of less than 1 per cent. of oil differed radically in theory and effect from other processes in which more than 1 per cent. of oil was used. This decision forced other companies either to use more than 1 per cent. of oil or to pay royalties to the successful litigants. In many cases the former alternative has been taken. Dealing with the consequences of the decision, H. A. Mcgraw states, in *The Engineering and Mining Journal* of May 5, 1917, that he has been able to examine the records of several plants in which more than 1 per cent. of oil is now used. He finds that the extraction has improved as more experience is being gained; the improvement is slow; however, the improvement in the concentration grade is still slower, and consequently the working costs remain higher than they were before, when the minimum quantity of oil was used. In one case, where the available water was very dirty with slimes, the extraction was distinctly better with more oil, and the concentration grade did not go down. Some 5,000 tons of ore are said to be treated daily with more than 1 per cent. of oil.

BURFORD-CLEVELAND TRACTOR AND "ONCE-OVER" TILLER.

MESSRS. H. G. BURFORD AND CO., LIMITED, ENGINEERS, LONDON.

(*For Description, see Page* 63.)

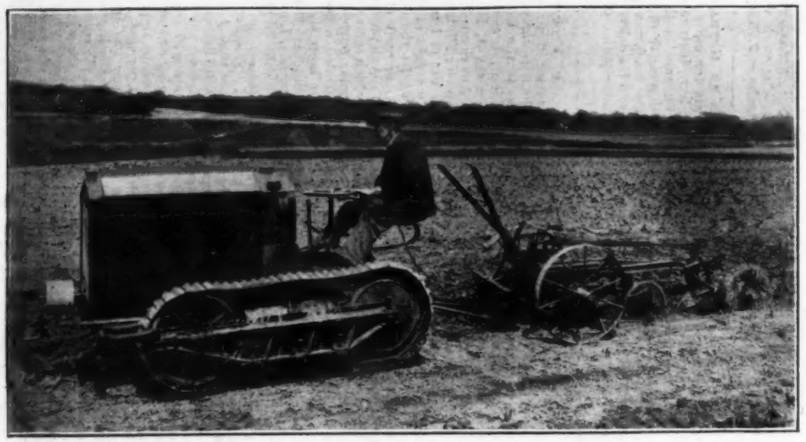


FIG. 3. TRACTOR WITH PLOUGH.

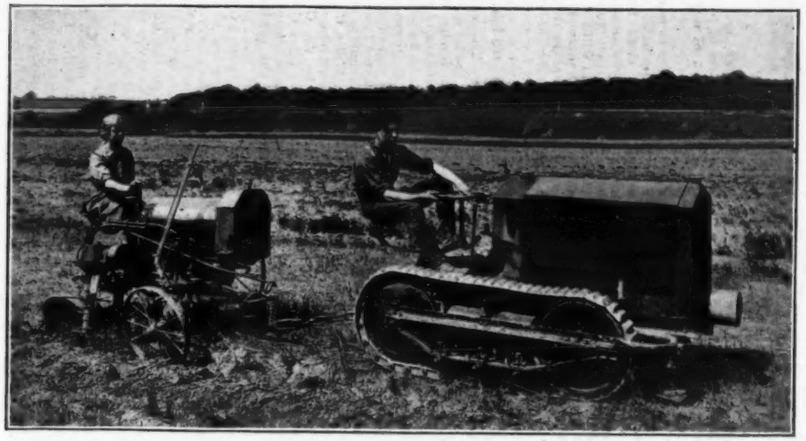


FIG. 5. TRACTOR AND TILLER.

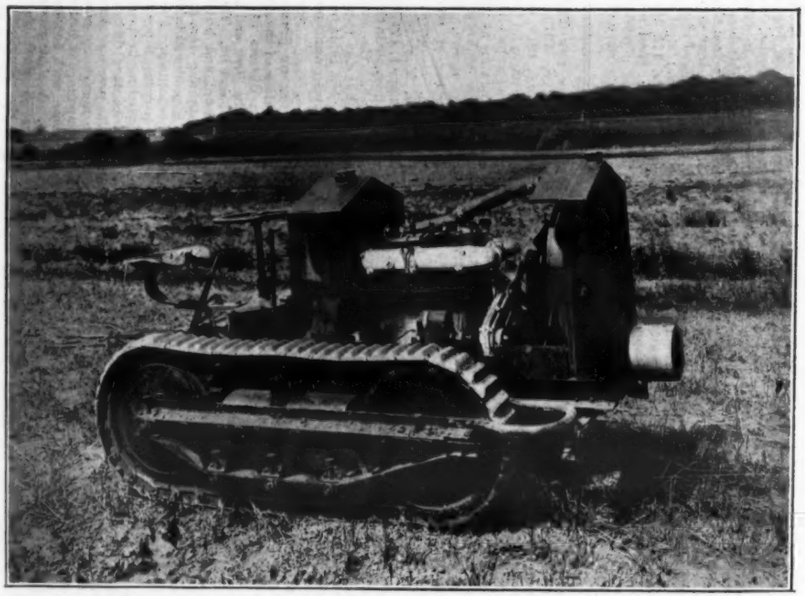


FIG. 4. TRACTOR WITH BONNET REMOVED.

FIG. 6. TRACTOR WITH HARVESTER.

LANCASHIRE AND YORKSHIRE RAILWAY COMPANY'S GHENT AND ANTWERP SHED AT GOOLE DOCKS.

MR. D. C. RATTRAY, CHIEF CIVIL ENGINEER, AND MR. G. HUGHES, CHIEF MECHANICAL ENGINEER, TO THE RAILWAY COMPANY.

(For Description, see Page 58.)

FIG. 10. VIEW FROM ONE OF THE BAYS LOOKING TOWARDS SIDINGS.

FIG. 11. VIEW OF SHED LOOKING ALONG SIDINGS.

(To face page 60.)

LANCASHIRE AND YORKSHIRE RAILWAY SHED AT GOOLE; 30-CWT. SLEWING UNDERHUNG JIB CRANE.

MR. D. C. RATTRAY, CHIEF CIVIL ENGINEER, AND MR. G. HUGHES, CHIEF MECHANICAL ENGINEER, TO THE RAILWAY COMPANY.

(*For Description, see Page 58.*)

Fig. 12.

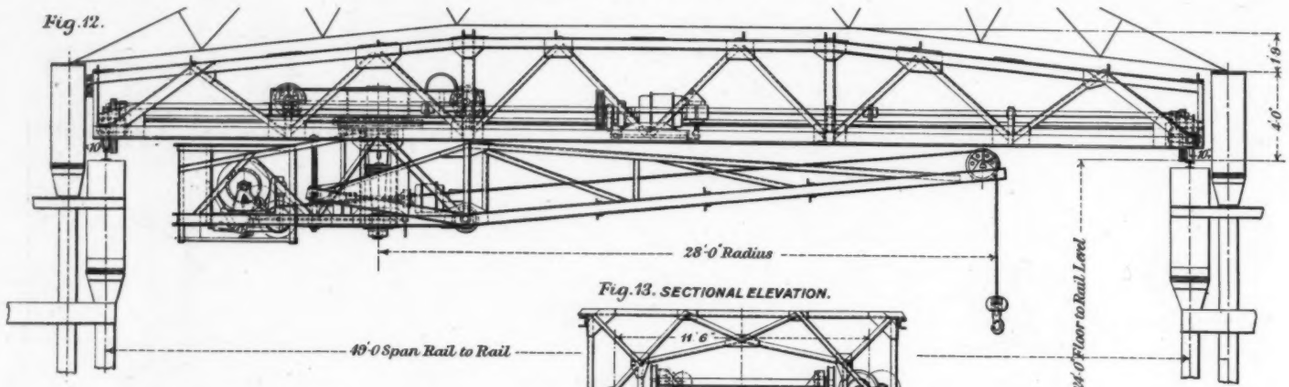


Fig. 13. SECTIONAL ELEVATION.

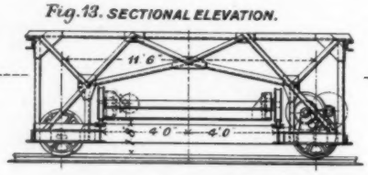


Fig. 14.

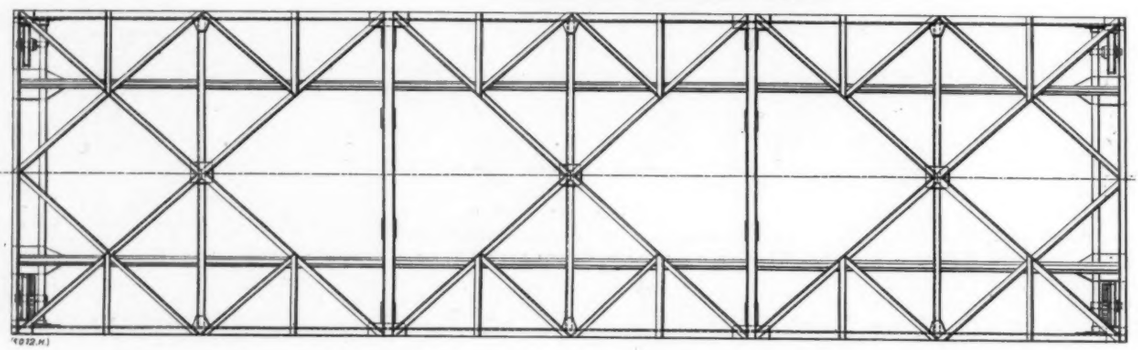


Fig. 15.

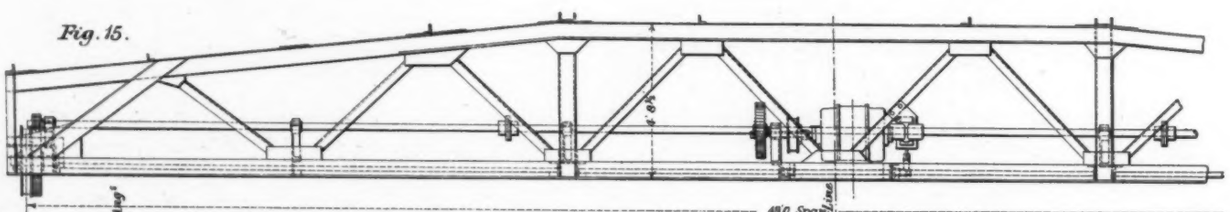


Fig. 16.

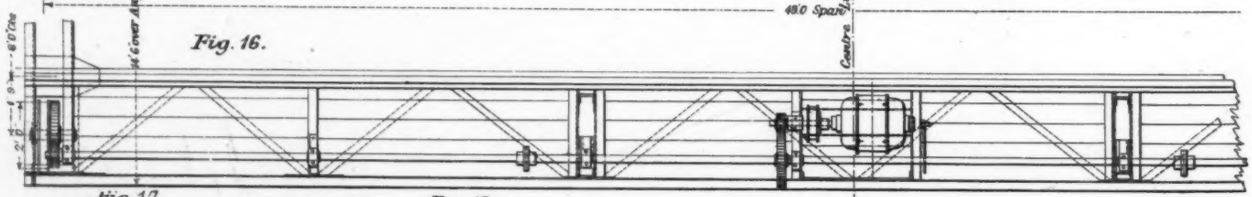


Fig. 17.

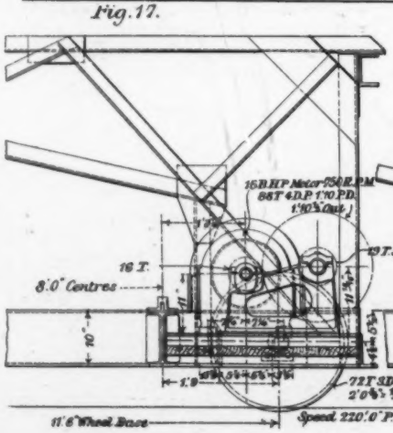


Fig. 18.

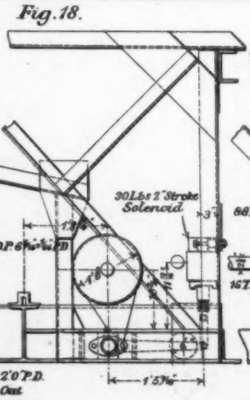
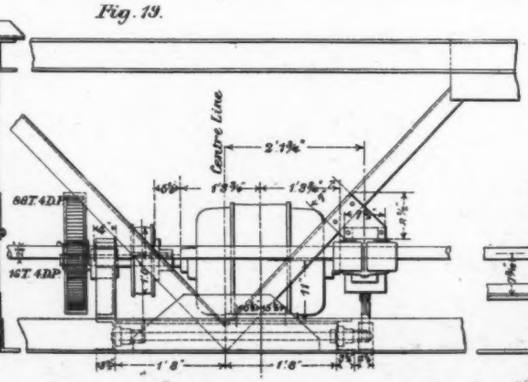


Fig. 19.



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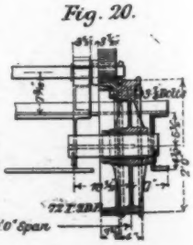
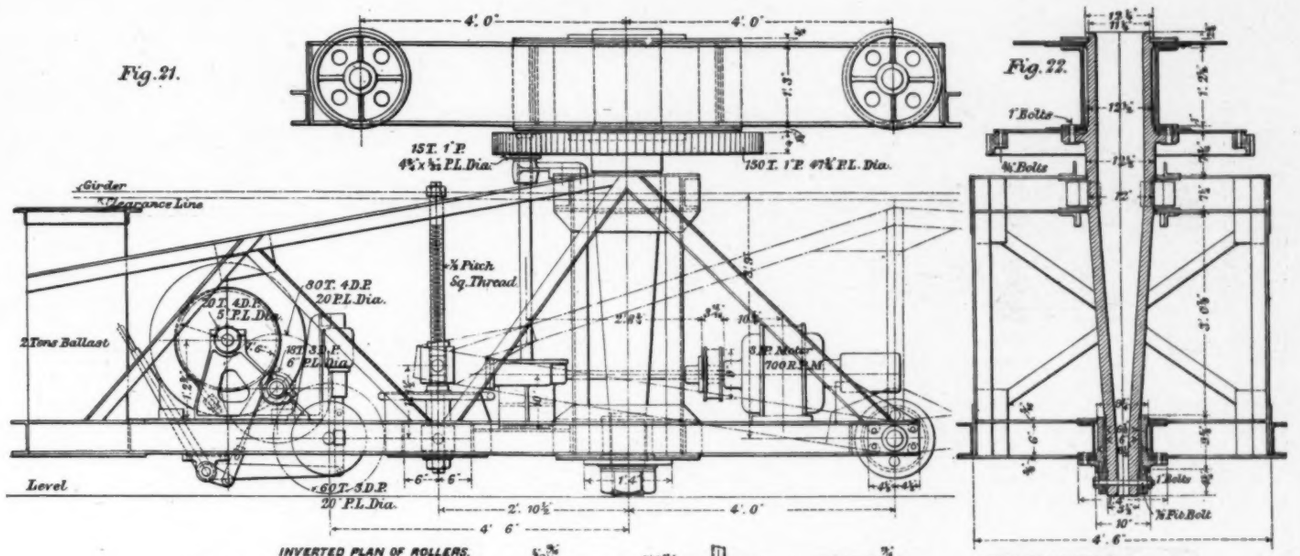
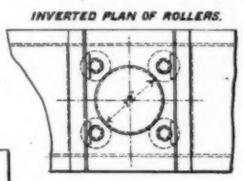


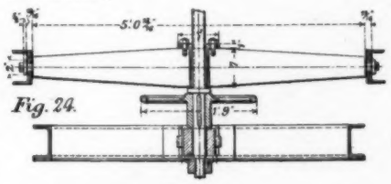
LANCASHIRE AND YORKSHIRE RAILWAY SHED AT GOOLE; 30-CWT. SLEWING UNDERHUNG JIB CRANE.

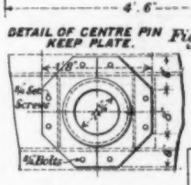
MR. D. C. RATTRAY, CHIEF CIVIL ENGINEER, AND MR. G. HUGHES, CHIEF MECHANICAL ENGINEER, TO THE RAILWAY COMPANY.

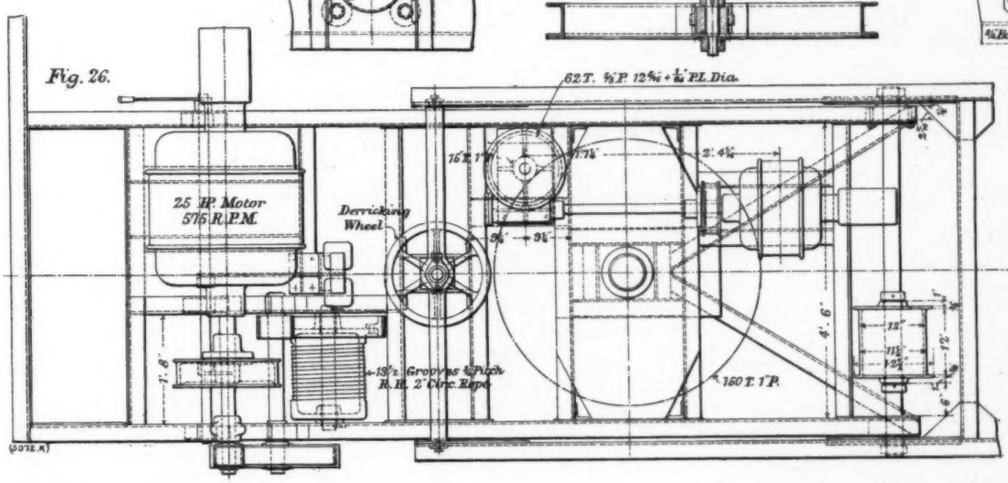
(For Description, see Page 58.)

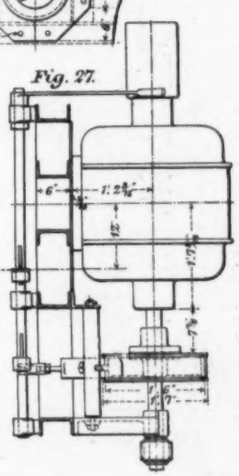


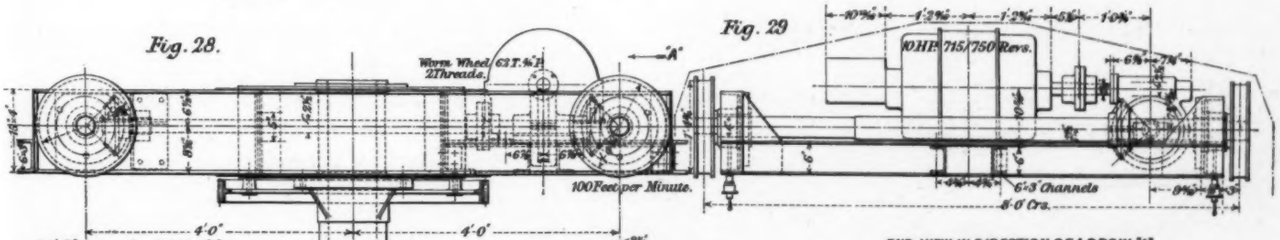


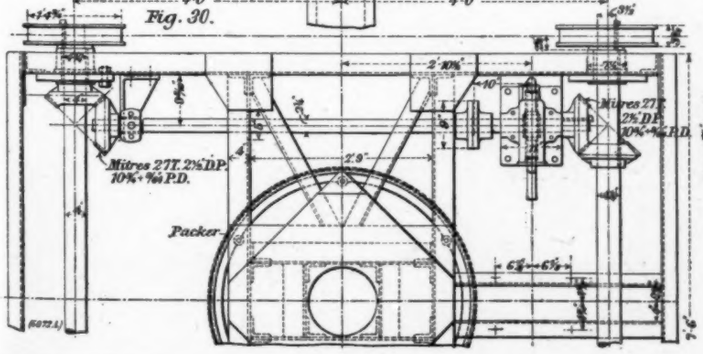


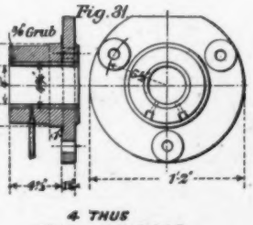


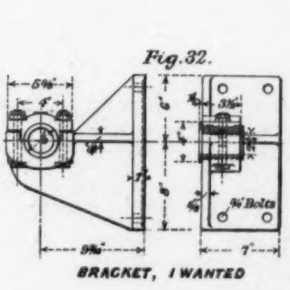










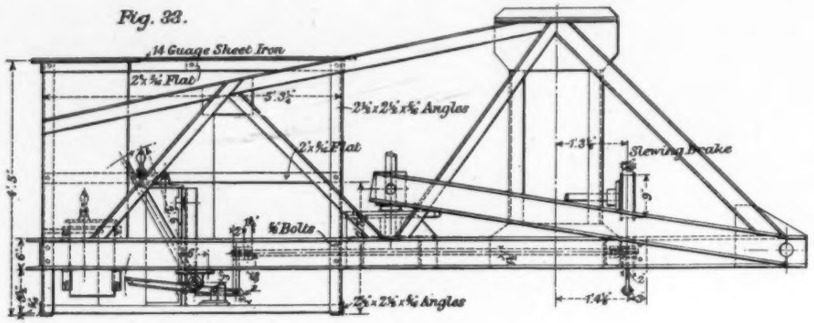


LANCASHIRE AND YORKSHIRE RAILWAY SHED AT GOOLE; UNDERHUNG JIB CRANE.

MR. D. C. RATTRAY, CHIEF CIVIL ENGINEER, AND MR. G. HUGHES, CHIEF MECHANICAL ENGINEER, TO THE LANCASHIRE AND YORKSHIRE RAILWAY.

(*For Description, see Page 58.*)

Fig. 33.



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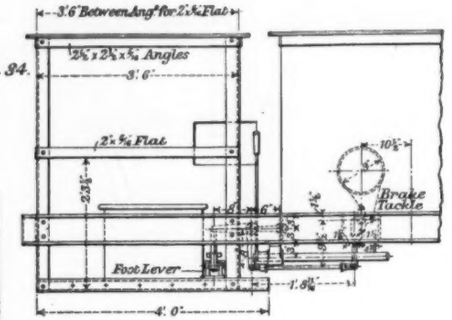

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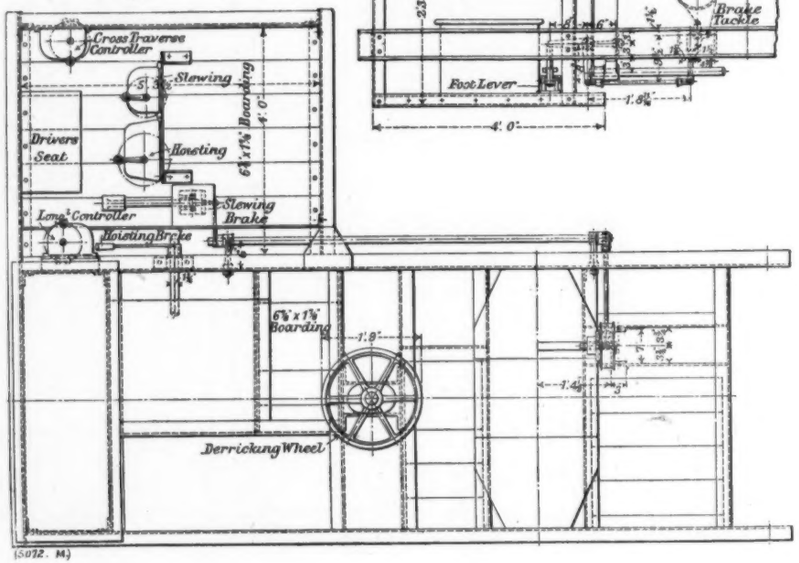

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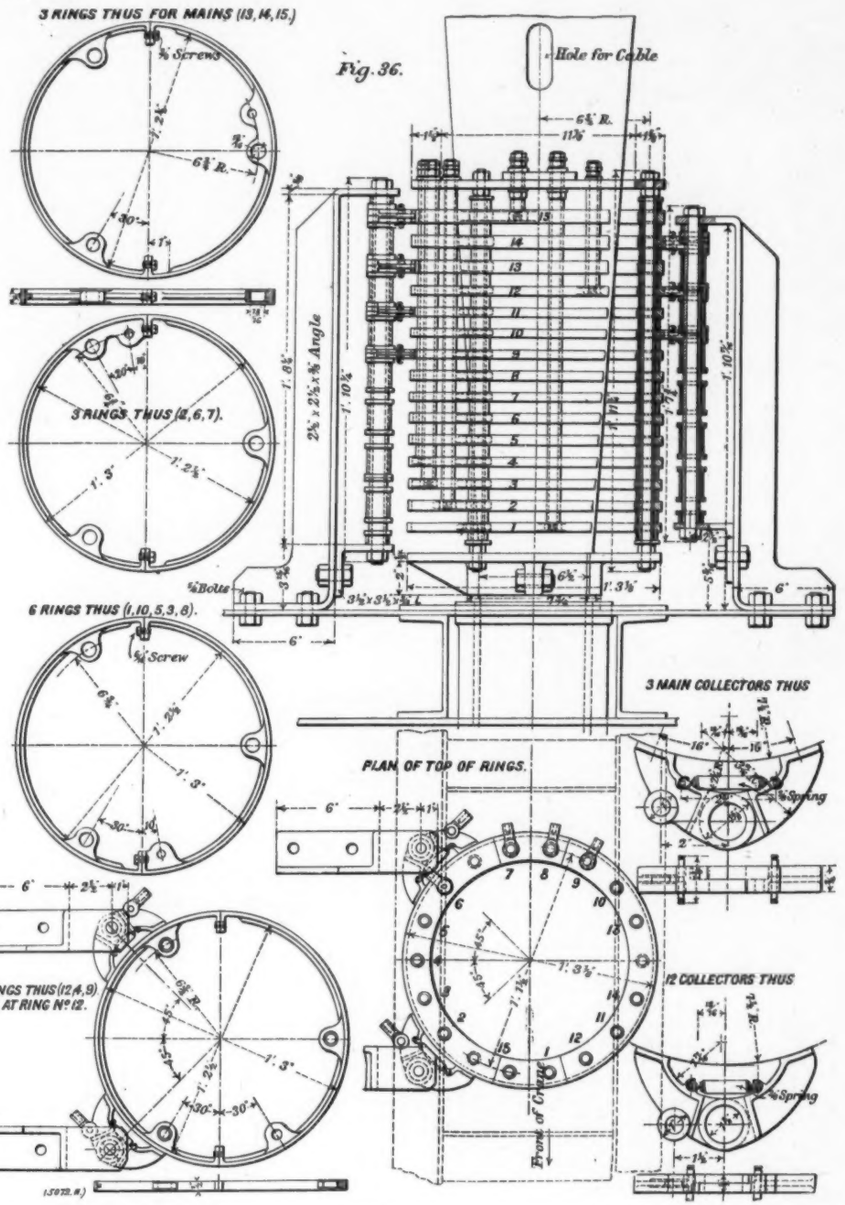

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With Four One-Page Plates of the LANCASHIRE AND YORKSHIRE RAILWAY COMPANY'S GHENT AND ANTWERP SHED AT GOOLE DOCKS.

NOTICE OF MEETING.

THE MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.—Thursday, July 26, at 3 p.m. The annual general meeting of the members of the Institute will be held at the University, St. George's Square, Sheffield. At 3.30 p.m. a lecture on the "Forests of the Coal Age" will be delivered by Dr. D. H. Scott, F.R.S.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal from 6d. to 8d. per copy. This increase dated from and included the issue of Friday, March 16. The change will not apply to unexpired subscriptions.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, JULY 20, 1917.

"TIME AND LINE."

A LARGE number of contracts made for the manufacture of munitions of war are on the "time and line" basis, the idea being that excess profit is thereby obviated. This result may be achieved, but it is pertinent to inquire whether there is, in the end, a saving in the actual cost of production. Too much attention has been given to this question of profit, and the application of the "time and line" principle, for the reasons stated, is not justified, in view of the more comprehensive principle of taxing the excess profit made by all manufacturing and other concerns throughout the country under the Finance Act. The spending departments of the Government should be less concerned with manufacturers' profits and pay more heed to the cost of production, especially as it is possible to check the price demanded by one firm against that exacted by another. At one end of the manufacturing scale there is very properly the demand that all workmen should be paid by result, and yet at the other end the tendency is to pay on the basis of labour and material, plus a percentage for establishment charges and profit. This latter, it will be recognised, cannot be regarded as payment by result in the same sense as where piece-work or premium bonus rates are the basis for the workmen.

We admit that in the early stages of the war, when many firms with no experience in the manufacture of war material had no data on which to form estimates of cost, there was some justification, only due to war urgency, in applying the principle of "time and line"; but the practice has been continued, even with firms of the fullest experience. The conditions, of course, were abnormal, because the vital necessity was the early and adequate supply of munitions. As soon as the flow of material for the army reached the desired rate, there should have been an effort to overcome the disadvantage of this method of payment for supplies. The "time and line" system may be, and in many cases is, a premium on inefficiency and incapacity. The management know perfectly well that their profit is assured. Indeed, the longer the time taken and the higher the price chargeable for material, the greater is the sum of profit earned, since the percentage receivable is on a higher total labour and material cost. This applies also to establishment charges. With this knowledge, it is not in human nature to make the same effort to keep down cost as where a fixed price is payable, and where saving accrues to the firm and redounds to the credit of the management. It is almost impossible to prevent even the workmen from knowing that they are engaged on a "time and line" contract, and those responsible for management are often met, in these days of trade-union dominance, with the remark that the foreman or manager need not concern himself with details affecting the cost of production, as the establishment is controlled and the Government are in reality the paymasters. Consequently, public money is wasted, irrespective of the effort of those responsible for checking, on behalf of the Government departments, the relative cost of the work done in various establishments.

Another and equally disadvantageous element enters into the question. The determination of the rate for establishment charges is one of grave difficulty. All works cannot be rated on the same basis; the more efficient the factory becomes, the higher the rate involved in establishment charges and the lower the cost for labour. Side by side there may be works engaged on the same manufacture, in one of which efficiency is the dominant consideration, and there, to begin with, the staff has been organised so as to achieve the highest degree of mentality in the management of the works and to ensure the strictest economy in all details—for instance, to mention but a few important items, in the suitability and quality of coal used, in the generation and transmission of power, in the choice and application of machinery for the work required to be done, in minimising handling, and generally in reducing to the lowest possible limit the proportion of man-power involved. The other works may belong to the old school, where what has been good enough for a man's father and grandfather is considered good enough for him, and where there is practically no effort made towards improvement or the speeding-up of production. Thus in the one case the staff expenses and on-cost charges, as well as the rate for depreciation and for equally important obsolescence, must necessarily be high, whereas in the other instance the rate for establishment charges will be comparatively low. In the former case, however, labour is placed in the most advantageous position; because, owing to the principles applied, the output is enormously increased and the cost per unit manufactured greatly reduced, while at the same time the weekly wage earned by the worker is greater. As a result, happier and more prosperous conditions prevail, and the nation is better served, equally in war time as in peace. How can a Government department estimate the percentage which should be paid to each factory on "time and line" cost in order to cover the establishment charges? Every case must be judged on its own merits, and the facts can only be disclosed by consideration of pre-war accountancy. There comes in, however, the disturbing element of abnormal conditions due to the war. Thus economy requires that the practice observed in payment for supplies should come down to the rock basis of estimated cost or competitive tendering.

Apart from these difficulties, the "time and line" principle may have lasting injurious effects on efficiency. Human nature makes us all prone to choose the easy road. We acquire indifferent habits more easily than we can rid ourselves of them, and where, for a period of a year or two, there is removed the stimulus consequent on competition the effect becomes serious. The manager has the edge of his keenness blunted in his visits to the shops. At first he recognises lapses from efficiency and method, but inclines to neglect them, because under the "time and line" system they do not matter; ultimately he fails to see them at all. The foreman is not only affected by the laxity of the manager, but comes under the influence of his own personal weakness, while the men are more ready to demand concessions and are less disposed to make effort. Some works have been employed on the "time and line" system now for a long period. The day will come when competition will demand the most strenuous effort towards efficiency in order to reduce cost of production, and it becomes of the highest importance that the mentality of works management should be intensified rather than atrophied as it tends to be under the system with which we are dealing.

The system is particularly injurious to the works where an effort is made towards efficiency in every respect, because, even with a conscientious desire on the part of those responsible for the management to maintain the high standard, they feel placed at a grave disadvantage, because of equality of treatment with less efficient concerns. In other words, if, at present, the competitive system were resorted to, the improvements and mechanical

(To face page 61.)

applications whereby cost is reduced would have their rightful reward in securing orders under that system. All concerned in a works are gratified in triumphing over their competitors in the acceptance of their tender. There is for all a greater volume and a more constant continuity of work. And, finally, there is the consciousness of realised aims where the happy condition prevails of the actual cost being within the estimate. This is apart from the growing practice of members of the staff being presented with a bonus for such successful issue of the effort made.

ACOUSTIC EFFICIENCY OF FOG-SIGNAL MACHINERY.

IN 1873 the Trinity House Corporation conducted a long series of experiments from the South Foreland on the audibility of fog signals. A committee of the Elder Brethren had paid a visit to the United States in the previous year, and they had the assistance of their scientific adviser, Professor Tyndall, whose memoir on the "Atmosphere as a Vehicle of Sound" was published in the Philosophical Transactions of 1904. The main conclusions of the Trinity House report were: The passage of sound is not impeded by fog or by falling snow and rain; the most powerful sound-producing instrument is the siren in use in the United States, but even that could not be relied upon at distances exceeding 3 miles; sound shadows (zones of silence) are formed by the intervention of the shore or interference of sound waves; an opposing wind greatly obstructs and diverts the sound waves, and even a clear atmosphere may be rendered flocculent to sound by invisible acoustic clouds formed by air currents of different temperatures and humidity. It is difficult to harmonise the first and the last of these conclusions. In these experiments the audibility was entirely estimated by the ear, on which the navigator himself relies, of course; but individual imperfections may seriously affect the results. In the experiments of 1874, by the United States Lighthouse Board, Joseph Henry attempted physical estimates of the sound intensity by making use of Chladni figures; in general, the report of General Duane and himself agreed with the Trinity House report, though Tyndall and Henry clashed as to the interpretation of certain phenomena. In the further American experiments of 1894, by Livermore, White and Hazen, quantitative estimates of the sound intensity were made and entered on the charts of the ship tracks by the breadth of the line marking the track.

When, in 1901, Trinity House resumed the investigation from St. Katherine's Point, Isle of Wight, Lord Rayleigh was their scientific adviser and Sir Thomas Matthews their engineer. Rayleigh's contribution to the *Philosophical Magazine* of 1903, on the "Production and Distribution of Sound," dealt chiefly with the scientific side of the problems. Disc sirens proved superior to cylinder sirens, especially in calm weather; of reed horns, the stentor answered best. For sending sound in all directions mushroom-head trumpets were found efficient, and the elliptical form of Rayleigh gave better results than the circular form. For calm weather a low pitch (180 periods) seemed recommendable; a note of high pitch penetrated further against an opposing wind. Raising the air pressure above the usual 25 lb. per square inch proved of little use. The most striking resulting feature was the very low acoustic efficiency of the sirens. To make a siren audible 8 miles out at sea required 100 h.p. on a favourable day; the high note consumed 130 h.p.; with the 7-in. disc siren the maximum pressure change (condensation) observed in the sound wave was only 1/180 atmosphere when the siren was worked at 25 lb. pressure. Clearly there was much waste of energy in the siren and its trumpet. The chief interest in the French experiments of 1908 by C. Ribière lies in his attempts to find suitable methods of measurements. He tried membranes, phonographs, interferometers, &c., with some success in the laboratory, but none of his methods would answer on ships or in boats. But he drew attention to a point long since known, but insufficiently studied and appreciated, viz., that explosive waves (from detonations, guns, &c.) travel at higher speed than sound, and he considered the waves from sirens to be of this explosive character. This point requires consideration.

In his "Théorie du Son" of 1808 Poisson had already pointed out that only infinitesimal sound waves would be propagated at constant length and velocity. But he did not develop the theory. This was done by Earnshaw, Riemann, Rankine, Stokes, Hugoniot and, finally, by Rayleigh, in 1878 and 1910; yet there are difficulties left. The crests of finite, large waves tend to gain on the troughs; the crests thus become steeper, and finally overtake the troughs, and discontinuity (or a bore) sets in. Across a surface of discontinuity there is an abrupt change of density and velocity; the wave as such breaks up; viscosity and thermal conductivity tend to check the discontinuity. According to Rayleigh, the only wave which can escape ultimate discontinuity is a wave of rarefaction (not a wave of condensation), which has no forward slope. But he studied the phenomenon chiefly with respect to the discontinuity wave in front of a flying bullet, and did not dwell on the actual propagation of air waves at speeds exceeding that of sound. P. Duhem, 1909, spoke of propagation *des ondes de choc*, which is perhaps a more explicit term; but he also treats the subject mathematically. Vieille found that detonation reports (high explosives) were propagated at two and three times the velocity of sound. When he ruptured a thin metal diaphragm by a pressure of 27 atm. he observed twice the velocity of sound.

For these reasons instruments suitable for quantitative measurements on sound waves may be unsuitable for the study of siren signals. That was the consideration from which Dr. L. Vessot King, of Cambridge, started experimenting when at McGill University, Montreal. Dr. King became interested in these problems when cruising with Professor H. T. Barnes in the Gulf of St. Lawrence, in his studies of iceberg dangers. He appealed to Professor A. G. Webster, of Clark University, Worcester, Mass., whose "Complete Apparatus for the Measurement of Sound" was mentioned in our British Association report of 1910,* and with the aid of the Webster phonometer, of a thermodynamical instrument of his own, and of the diaphone of Mr. J. P. Northey, of Toronto, he has been able to enter upon an inquiry into the acoustic efficiency of fog-horns, which promises to help the engineer to better types of fog-horns and to supply him with a basis for the science of acoustic engineering, a branch so far densely enveloped by that haze which the navigator has so much reason to dread. Last winter Dr. King lectured in the Franklin Institute on his experiments, which the war interrupted (see Journal of the Franklin Institute, March, 1917). We will first describe the diaphone.

In the Northey diaphone, which has found favour in Canada, a hollow piston moves in a horizontal cylinder which is surrounded by an exterior stationary cylinder. The latter is charged with air at a pressure of 25 lb. per square inch, and the compressed air enters the piston when circular slots in the piston communicate with similar slots in the inner cylinder; the movement of the piston is produced by an arrangement of the compressed-air riveter type. The air leaves the piston through a short conical trumpet, which is said to yield a pure note (pitch, 180 periods) at great distance, even when the working air pressure fluctuates considerably. The diaphone gives two blasts of 3 seconds each per minute. One peculiar feature of the diaphone note was quite unexpected, but was afterwards purposely emphasised. At the end of a blast the piston slows down, and as a result the pitch diminishes to a powerful terminal note, a "grunt," which helps sailors to determine the direction of the signal and to distinguish it from ships' sirens.

To understand the difficulties of the phonometer we must remember that the actual changes in air pressure, and in the displacements of air particles to which a travelling sound wave give rise, are very small. Experimenting on just audible sounds of pitch 181 (the pitch of the diaphone, it will be noticed), Boltzmann and Töpler observed, in 1870, air-pressure changes amounting to 9.2×10^{-6} atm. and displacements of 0.19×10^{-6} cm., whilst Rayleigh (1877) found 6×10^{-6} atm. and 0.127×10^{-6} cm. for the higher pitch of 256. Now the wave-length of yellow light is only 6×10^{-6} cm., and according to Rayleigh the stream of energy, *i.e.*, the amount of energy in just audible sound waves crossing unit area per second, is about the same as that of an ordinary candle seen at a distance of 3,000 m. Thus the human eye and ear respond to approximately the same minimum energy, though the ear is otherwise considered the more perfect organ, as it is sensitive to a far greater range of frequency.

The intensity of light and sound is supposed to decrease with the square of the distance. But that law is not more than a rough approximation in the case of sound. Taking Boltzmann's figures, King calculated that the expenditure of energy at the resonator of the acoustic waves, which he heard at 10 miles distance (which was not the maximum attained) should have been less than $\frac{1}{3}$ h.p., assuming the inverse square law to hold, whilst the engine was actually working continuously at 10 h.p. to compress air for the very short blasts. We have already called attention to the excessive power absorbed by the Scottish siren at St. Katherine's Point. These results suggest both waste of power in the machinery and the inapplicability of the inverse square law, *i.e.*, sound waves are not propagated through air without loss of energy.

The Webster phonometer is a Helmholtz resonator consisting of two cylinders sliding the one inside the other so as to make volume and pitch adjustable. The one end of the cylinder is pierced by a small hole, the other closed by a mica diaphragm. With ordinary sound waves the vibrations of this diaphragm can only be measured by optical interference; this is done with the standard laboratory phonometer. The instrument of King operates somewhat like a combined phonograph and mirror galvanometer. A steel point is attached to the diaphragm and presses against a steel strip carrying a concave mirror; the vibrations tilt the strip, and a wavy band is produced, the width of which is a measure of the amplitude of the waves. To calibrate a phonometer, another of these instruments is used as a sound producer or phone. In this way Webster found the acoustic efficiency of a violin to be 0.00052, that of a cornet twice as great, and that of the human voice 0.0095, or nearly 1 per cent., a surprisingly high figure. The King phonometer was used on board. But it was not suited, owing to the explosive character of the siren waves, for energy measurements at the diaphone. In those measurements King depended upon determining the lowering of the temperature by the expanding air. Coils of fine iron wire (0.001 in. thick) were suspended by silk threads in the valve on the compressor side and in the trumpet, about 5 in. in front of the piston; and the temperature difference between the two coils was measured by means of a bridge and a portable galvanometer. Compensation had to be applied for the heating of the coils by the air rushing past them.

With these instruments Dr. King, assisted by Mr. H. H. Hemming, conducted observations in August and September, 1913, from the fog-signal station at Father Point, near Rimouski, on the southern bank of the St. Lawrence, the width of which there already exceeds 30 miles, at the station and on the tender Lady Evelyn, or on a boat. Taking as his efficiency unit the amount of work that air at a certain compression would be able to do on an adiabatic cycle if all the energy were converted into sound in the diaphone, Mr. King obtained efficiencies of 6 per cent. and even 8 per cent. at pressures of 20 lb. per square inch (above the atmosphere), and he considers that in the since-improved diaphone that efficiency has been doubled. In one of his best experiments he calculated that power was being transmitted across an area of 14 sq. in. (5 in. from the piston) at the rate of 2.36 h.p., *i.e.*, that amount of horse-power was utilised in sound transmission; the pitch was 175 periods; the amplitude of pressure 0.128 atm., of displacement 1.08 in., the maximum velocity of a particle in the sound wave 99 ft. per second, and the average velocity of the air, deduced from the rate of air consumption, 137 ft. per second. The compression and rarefaction of the air (at about 0.1 atm. pressure fluctuation) should give rise to temperature fluctuations of 12 deg. C., and the

* See ENGINEERING, vol. xl, page 452.

sound wave from the diaphone would soon become discontinuous; but the experiments could not be resumed in 1914 to investigate these problems.

The position of the ship or boat (the latter up to two miles from the station) was determined by sextants, and meteorological observations were also taken. The ship's course was traced on the chart, as above-mentioned, on a line the thickness or width of which indicated the observed intensity of the sound. Thus a wavy line was obtained, thick and irregular near the shore, where the pier and shore features interfered with regular sound propagation, and becoming thinner and more regular at greater distance, and not showing sometimes any very marked diminution in intensity with distance. One of the few charts reproduced extends to a distance of 8 miles, and the sounds appear to have been stronger again beyond 6 miles and to have lost little in intensity during the last 2 or 3 miles. The swellings to the right and the left of the line were not equal generally, probably because the wind was mostly blowing from one side. The wind proved to be the predominant factor in the variability of the sound propagation; but there were also zones of silence, and the wavy swellings distinctly show a periodicity to which Dr. King merely refers. Two charts, also reproduced, concern trips on the tender in circular arcs about the lighthouse as centre, one at a radius of about half a mile, the other at 1 mile; here the shore influences are very strong; the pier cut off almost all the sounds near the shore.

Much further experimenting will, of course, be required. But the new instruments should be of great assistance in the design of fog-horns and also in selecting the proper site for fog-horn stations, a question of equal importance.

FRENCH IRON ORE DEPOSITS.

IN a recent article (see pages 541 and 575 of our last volume, June 8 and 15) we gave an account of the great efforts the German iron and steel manufacturers had made to obtain control of the iron ore deposits in France, either directly, or indirectly by forming French companies in which they had a controlling voice. Germany is not well endowed by Nature with iron ore, and has to look abroad for much of its supplies. Further, the basic process of steel manufacture has been developed there on a large scale, and this requires phosphoric ores, which are plentiful in France. There were thus two reasons why the power of German finance should be used to secure a hold on French mineral supplies. What those supplies amount to will be understood from the article below, which deals with the various deposits individually, explaining their extent and richness.

The French iron ore deposits of special importance are those of the minette ore in the department of Meurthe-et-Moselle, and those of Normandy.

The former are part of the vast iron ore deposits which extend beyond France, over portions of Belgium, Luxemburg and German Lorraine. The areas of these deposits in the countries in question are as under:—

	Acres.
France	150,743
German Lorraine	106,262
Luxemburg	9,143
Belgium	950

The French portion of these deposits is divided into three basins, that of Longwy in the north, that of Briey in the centre, and that of Nancy in the south, separated from the former by a barren zone of about 19 miles. To the latter district must also be added the ore deposits of Crusnes, discovered within the last decade and covering an area of some 24,712 acres; but this latter district has not yet been opened out.

The minette iron ore consist of grains—ooliths—connected by lime or silicates, and is found between slaty or limestone strata, often of considerable depth and extent, though only one, the "grey layer," extends over the whole district, with a thickness of as much as 30 ft. The percentage of iron varies in the different deposits. In German Lorraine and in Luxemburg, as well as in the Longwy and Nancy deposits, the proportion of iron generally ranges between 28 per cent. and 33 per cent., whilst the average percentage of iron in the Briey ore amounts to 37 per cent. and, as far as several mines are concerned, to even as much as 40 per cent. The appended table gives some details of the percentage of iron from different mines:—

	Per cent. of iron.
Sancy mine	39.90
Pienne mine	40.65
Landres mine...	40.61
Auboné mine	38.64
Joeuf mine	37.29
Montiers mine	38.24
Murville mine	36.43

The production of iron ore in the French minette district has increased at an exceptionally rapid rate. In the year 1860 it amounted only to 331,000 tons, and only accounted for 11 per cent. of the aggregate French production of iron ore, 3,033,000 tons. The phosphoric ores of the minette basin were almost neglected at the time, for the iron produced from them was of somewhat inferior quality and could only be used for certain purposes. It was not until the basic process of Thomas and Gilchrist was developed, in the year 1879, that the minette ore became a valuable raw material. This gave a great impetus to its working, and when the Briey deposits were discovered and opened out the output of iron ore in Eastern France rapidly rose. In the year 1887 it had already reached a total of 1,953,000 tons, or 75 per cent. of the aggregate production of iron ore in France. Ten years later the figures were, respectively, 3,804,000 tons and 85 per cent., and in 1911 14,828,000 tons and 91 per cent. The two following years witnessed a further increase in the output of iron ore from the deposits in the Meurthe-et-Moselle department, the figures being respectively 17,235,000 tons and 19,813,000 tons. This vast increase is due to the Briey deposits, in which, on account of the expensive plant required, production had to be on a large scale. The production of the two other basins seems to have reached its limit, and shows no material difference for the last few years. This will further appear from the subjoined table:—

—	Deposits.			Aggregate Production in the Meurthe-et-Moselle.	Total Production in France.
	Nancy.	Longwy.	Briey.		
	Tons.	Tons.	Tons.	Tons.	Tons.
1875	976,000	—	—	—	—
1885	600,000	1,012,000	—	1,612,000	2,318,000
1895	1,330,000	1,748,000	6,000	3,084,000	3,660,000
1905	1,713,000	2,333,000	2,353,000	6,399,000	7,395,000
1910	2,091,000	2,607,000	8,505,000	13,210,000	14,606,000
1911	2,051,000	2,350,000	10,427,000	14,828,000	16,000,000
1912	1,968,000	2,305,000	12,717,000	17,235,000	18,840,000
1913	1,912,000	2,440,000	15,147,000	19,813,000	21,714,000

The iron ore deposits of the department of Meurthe-et-Moselle are of great thickness and are calculated to contain some 3,000,000,000 tons, distributed amongst the different basins as under:—

	Tons.
Nancy	200,000,000
Briey	2,000,000,000
Longwy	300,000,000
Crusnes	500,000,000

Besides these vast deposits a new iron ore district has been opened not long ago, viz., that of Normandy, extending over the departments of Calvados, Orne and Manche, which, according to the investigations undertaken so far, comprises an area of some 39,539 acres. These deposits have really been known for a long time, and some ore had been worked in earlier days, but the great French revolution brought this industry to a standstill, only some names still bearing witness to this fact. It is only during the last four or five decades that some interest has again been taken in these deposits, and the first concession, granted to two French engineers in the year 1875, had reference to some deposits in the department of Calvados, those of St-Rémy; while in 1893 a concession was granted for the St-André deposits. By the year 1910 the number of concessions had risen to 20. The iron ore deposits in Normandy so far worked belong to the Silurian, and the veins extend in the direction of east and west and south-west; in the east they are covered by the Jura. Near the surface the ore is hematite, but lower down it changes into carbonate. At present four districts are known, those of Maysur-Orne, Barbery, Falaise and Ferrière-aux-Etangs. The thickness of the layers amounts to as much as 20 ft. The ore contains up to 53 per cent. of iron; the raw carbonate contains about 40 per cent., and when roasted 50 per cent., with a low percentage of manganese. The residue amounts to 14 per cent. to 17 per cent., lime to 2.5 per cent. to 4.5 per cent., and phosphorus to 0.6 per cent. to 0.8 per cent.

The growth of the iron ore industry in Normandy will appear from the following table:—

	Tons.
1902	162,000
1903	202,500
1904	217,400
1905	258,300
1906	292,500
1907	325,700
1908	356,800
1909	425,000
1910	550,000
1911	609,000

It must be remarked in this connection that the concessions have been worked only to a comparatively small extent so far; most of them still remain in a preparatory state. About one-third of the ore production is worked up in France; of the other two-thirds the smaller half goes to England, and the rest, before the war, to Germany, *via* Rotterdam. The capacity of the Normandy iron ore deposits is estimated by different experts at a total varying from 110,000,000 tons to 700,000,000 tons.

AEROPLANE COMPASSES.

THE magnetic compass is one of those indispensable things which are a constant source of anxiety to the user. On a steel ship it is liable to erratic variations which give no sign of their existence, while it is practically useless on a submarine. When employed in a surveying instrument underground it is liable to be deflected by masses of ore and lead the user far astray Even in the hands of the military officer it is a troublesome aid from its instability and the ease with which it can be misread. But it is on an aeroplane that it exhibits the most bewildering vagaries, and where it is most necessary that it should be easily read and confidently followed. The airman has often to fly either above or through clouds, and unless he can see either the sun or the stars he must depend on the compass for his direction. At a speed of 60 miles to 100 miles an hour an error of a few degrees may land him far from his objective, or cause him to make a report which is not only inaccurate, but dangerously misleading. Such an error is very easy to make, for an aeroplane is in constant vibration, and every change of direction upsets the compass. The compass of an aeroplane flying on even keel is subject to the same errors as a ship's compass, and the errors due to iron and steel on the machine can be corrected in the same way as on board by the use of permanent magnets and of soft iron and by swinging the aeroplane. The transient error due to a slight turn of the machine is also of a similar nature; the disturbed compass card takes some time to come to rest again, because the card is carried round by the liquid in the bowl, and the centrifugal force acts chiefly on the heavier south end of the card.

The effect of the vibration can be largely neutralised by supporting the bowl which contains the liquid (alcohol and water) on soft washers, and by maintaining it in its normal position by spiral springs. The damping of the oscillations due to a large disturbance is a more serious question. A large magnetic moment means a rapid return; but if this be obtained by means of heavy magnets, prolonged oscillations will result. A small magnetic moment means a slow return, the motion being dead-beat or non-oscillatory; the difficulty in that case is the low stability of the system and the uncertainty of knowing whether or not the card has reached the equilibrium position. The greatest error of the compass is, however, that due to "banking," when the aeroplane is turning, as the card is no longer horizontal.

Many inventors have been at work to devise a compass which would be less susceptible to the numerous adverse influences which conspire to confuse its action on an aeroplane. Much that has been achieved is, of course, secret matter, but at a recent

meeting of the Optical Society Mr. S. G. Starling, B.Sc., who is head of the Physical Department of the West Ham Technical Institute, explained the principles on which he, in conjunction with Messrs. Henry Hughes and Sons, had attempted to produce a compass fitted for use on aeroplanes. Dealing first with the damping of the oscillations, Mr. Starling said that if M were the magnetic moment and I the moment of inertia of the system, H the horizontal terrestrial force, and K a couple due to friction or viscosity proportional to the angular velocity of the card, the return to rest would be oscillatory, dead-beat or quickest according as $4\,M\,I\,H$ was greater, smaller or equal to K^2. Most compasses were insufficiently damped, *i.e.*, K was too small. To get M as great as possible without increasing the I, he made his magnets of little steel tubes, filing the ends off obliquely until the inertia and demagnetising effect of the ends were suitably reduced. The new cards fitted with these floating magnets came to rest in 17 seconds, against 47 and more seconds.

If in banking no slide-slip occurred the resultant of the gravity force $m\,g$ and of the centrifugal force $m\,v^2/r^2$ (v being the velocity, r the radius of the turn) would be at right angles to the aeroplane base, and the card would keep the position with respect to the bowl which it had before the turn. The tilt of the card would thus be the same as that of the machine, and the card equilibrium would no longer be in the N—S direction of the magnetic meridian. When the equilibrium positions for a complete turn through 360 deg. were calculated from the vertical and horizontal components V and H of the terrestrial magnetic field, as Mr. Starling had done in the *Philosophical Magazine* of November, 1916, very peculiar results were obtained. For a tilt of 23 deg. (the complement of the magnetic dip at London), the card was in a neutral position when the course was magnetic E, because then the card was at right angles to the resultant magnetic field. At tilts greater than 23 deg. the error might reach 180 deg., i.e., the card might point S instead of N, on an easterly course; and the deviations for easterly and westerly courses were not symmetrical. Mr. Starling's curves, of course, did not indicate the actual position that the card would assume during flight, but the position towards which it was urged at any moment, corresponding to the position which an ideal compass would take up if it were capable of instantaneous return to equilibrium. That ideal compass would have great errors during the turn, but would be correct directly the turn was complete. Owing to inertia the actual card would have a smaller error (than the ideal) during the first part of the turn, but the effect would be cumulative, and the card would hence acquire velocity and overshoot the error, this after-effect being the greater, the more sluggish the needle.

To correct for tilting Mr. Starling uses two bar magnets, so fixed, symmetrically to the compass, with their N pointing downward to a tilting lever that the magnets remain vertical to the cards when the aeroplane tilts, and that their S—N field is equal and opposite to the V force. He further attaches correctors of soft iron to a "tilt measurer." The effective weight of a body A of mass m on the aeroplane, Mr. Starling explained, was itself affected by centrifugal force when the aeroplane was at a tilt ϕ and was equal to $m\,g/\cos\phi$. If A were attached to the centre of a spiral flat spring and provided with a pointer, the deflection of that pointer would measure the tilt; with the aid of this spring the correcting masses of soft iron could be approached to the compass as the tilt increased. In the error-eliminating compass, which Mr. Starling exhibited, two magnets were pivoted so as to be able to rotate; one end of each magnet was weighted, and the magnet was maintained horizontal by means of a spiral spring. In taking a curve the increased effective weight caused each magnet to tilt into a nearly vertical position and so to diminish the magnetic moment of the card. The error due to banking was hence reduced to a great extent, and the magnets resumed their horizontal position on the completion of the turn.

The discussion which followed the paper concerned chiefly the means to make the return of the card to equilibrium position as quick as possible. The preference for quick return seems natural. Captain Pierron considered long-period cards dangerous, though he had, as far as he knew, never been really endangered by the card pointing wrong; he had obtained very good results with a card of a period of 14 seconds. On the other hand, Dr. F. A. Lindemann, of the Royal Aircraft Factory, advocated long-period instruments for theoretical reasons; he did not, of course, in that connection refer to bowls, the liquid in which seems fixed and turns with the bowl. The problems are very complex, undoubtedly, and hardly admit of elementary mathematical treatment, as Mr. G. J. Bennett pointed out; the computation of the deviation from the true meridian is in itself a difficult matter. As long as the aeronaut can dispense with the compass and rely on land bearings, he does so; but when he cannot see land nor any thing else practically, he has recourse to his compass, though he knows that it may mislead him.

NOTES.

Fused Silica.

Some interesting data on the development of the fused silica industry are to be found in a paper contributed by Dr. F. Bottomley to the Newcastle section of the Society of Chemical Industry. The first practical success was, he stated, obtained by Boys, who showed that very fine filaments of silica could be produced by shooting lumps off softened quartz by means of a crossbow. Silica tubing and other articles were made by Shenstone in 1901, his raw material being rock crystal, which was also used by Heraeus for similar purposes in 1903. The cost of this material was prohibitive, and led to attempts to replace it by fused sand. After success was obtained at Wallsend the process was infringed by the Deutsche Quartz Gesellschaft, who lost their case in the subsequent litigation. In the process used at Wallsend the furnace used is, Dr. Bottomley states, of the electric-resistance type, the heating cores being plates, tubes or rods of carbon or graphite. The limits of temperature between which the process can be worked are very close, since the silica will combine with the carbon to produce carborundum at a temperature little above that required for working the silica. In making tubes or pipes the starting-point is a hollow cylinder of plastic silica, which is formed round the core through which the current is passed. These cylinders can in the plastic state be drawn into tubing, and from this tubing moulded articles are produced with the aid of compressed air. As much as 200 lb. weight of silica can be worked up at one time, and the products of the Silica Syndicate are now being used as acid-proof refractories in substitution for stoneware previously imported from Germany. Dr. Bottomley states that it is also being used for chimneys for incandescent gas lights, where the refractory character of the silica makes it possible to use chimneys of smaller diameter than are practicable with glass. This results, he states, in a higher temperature at the mantle and correspondingly better light.

A Soldered Molybenite Detector,

In 1911 L. W. Austin described a thermocouple, useful also as rectifier for high-frequency currents, consisting of a piece of tellurium and a platinum wire. Experimenting on similar lines, Professor C. Bergholm, of the University of Upsala, Sweden, found that molybdenite and quartz gave a very much more sensitive combination when soldered together by means of a platinum wire bent to a U, but that different spots of a molybdenite crystal behaved differently, and that it was necessary first to find the suitable spots of the crystals, which are scaly like graphite. In the *Annalen der Physik* of February 15, 1917 (vol. lii, page 102), Bergholm explains how he makes his detector or rectifier. The base of the instrument is a stout disc of ebonite, into which four holes are drilled. Two of the holes are horizontal in the direction of a diameter of the disc, two vertical; copper wires or rods are so fitted into the holes that they form the arms of two right angles, the horizontal arms serving as terminals, the vertical rods as supports. One of these vertical rods bears a cup of sheet copper, partly filled with Lipowitz alloy (of low melting-point); the crystal of molybdenite is embedded in enough of this alloy to be held firmly. A quartz crystal is not mentioned, and apparently the detector consists essentially only of molybdenite and platinum, the junction being effected with the aid of a bent platinum wire, extending from the cup and crystal over to the other copper rod. The first point is to find the suitable spot of the molybdenite crystal. For this purpose a rather thick platinum wire, 0.3 mm. in diameter, is first soldered to the copper rod not supporting a cup, and the free end of this wire is successively pressed against different spots of the molybdenite, while the detector is inserted in an electric circuit provided with a commutator. When certain spots of the crystal are touched, it will be observed, no current will flow; at others the current will pass in either direction; at others, again, the current will only flow in one direction. These latter unipolar points are the suitable points. The stout platinum wire is then replaced by a fine platinum wire, 0.02 mm. in diameter, which is soldered to the spot of unipolar current flow. This wire must be thin, lest the elasticity of the wire weaken the soldered joint. To facilitate the soldering a little gold is, by cathode volatilisation, deposited on the crystal. The description does not enter into particulars. Bergholm states, however, that his detector makes a very efficient rectifier, even for alternating currents of low frequency, and is much superior to others he knows, and that he is continuing his search for other unipolar combinations.

The Iron, Steel and Allied Trades Federation.

The second annual statistical report, for 1916, of the Iron, Steel and Allied Trades Federation, prepared by Mr. G. C. Lloyd, supervisor of the Statistical Bureau, has now been issued, and contains interesting information. The production of pig-iron in the United Kingdom during the year amounted to 9,047,983 tons, to which total Cleveland contributed 2,497,303 tons, followed by Scotland with 1,144,766 tons. The total production in 1915 amounted to 8,793,659 tons. In 1916 we imported 159,542 tons of pig-iron, and exported 922,380 tons, leaving as balance available for our consumption 8,285,145 tons. Our total number of blast-furnaces was 493, of which the average number active in 1916 was 295¾. An interesting detail to be noticed is that in 1916, for the first time in the history of the iron and steel industry in this country, the production of steel, 9,245,457 tons, exceeded that of pig-iron. The report remarks that the capacity for producing steel was very much increased in 1916, particularly as regards electric furnaces, and but for the shortage of labour and raw materials the output would have been considerably higher. The total for 1915 was 8,550,015 tons. The average number of converters active was 57 acid, 15 basic, total 72; and the average number idle 23 acid, 9 basic, total 32. The average number of open-hearth furnaces active was, acid 349½, basic 153, total 502½; and the average number idle, acid 82½, basic 26, total 108½. The electric furnaces numbered 32 Héroult, 22 Electro-Metals, 20 Greaves-Etchell, and 17 of six other types. The total quantity of finished iron amounted in 1916 to 953,472 tons, as against 1,015,911 tons in 1915; in 1916 there were 1,013 puddling furnaces active and 614 idle. The production of manganese ore in the United Kingdom in 1916 was 5,140 tons, as against 4,640 tons in 1915; and our imports of this commodity amounted to 439,509 tons in 1916, as against 372,724 tons in the preceding year. In 1916 Canada produced 1,069,541 tons of pig-iron and 1,286,509 tons of steel, of which 1,255,196 tons were ingots and 31,313 tons were castings, mostly of electric steel. Eight Canadian works made Bessemer, 11 open-hearth, 2 crucible and 8 electric steel. The figures relating to the other British countries overseas in regard to their development in metallurgy are also very satisfactory. The report further deals with the iron and steel industries of Europe and the United States, as far as figures for the various countries are available. From the data given we find that in 1916 the United States produced 39,434,797 tons of pig-iron, as against 29,916,213

tons in 1915; whilst Germany produced 13,259,000 tons in 1916 and 11,789,931 tons in 1915. In regard to steel, the output of the United States was 42,773,680 tons in 1916, and 32,151,036 tons in 1915; the steel output of Germany having been 16,035,000 tons in 1916, as against 13,258,054 tons in 1915. The report also refers to the British coal and coke output, and states the number of the different classes of coke ovens to be met with in this country. We have already dealt with this branch of our industrial activity on page 206 of our preceding volume, when analysing the last report of the Chief Inspector of Mines; it is only necessary to add that, from the Federation's report, our output of coal in 1916 was 256,348,351 tons, as against 253,206,081 tons in 1915, an increase of 3,142,270 tons.

THE HARDENING OF GAUGES.

The correcting of a screw gauge after it has been hardened in the ordinary way is a lengthy and laborious process which frequently ends in failure, and the desideratum is to carry out the hardening operation in such a way that practically no change occurs in any dimensions of the piece dealt with. As much was implied at the meeting of the Institution of Mechanical Engineers last January, after the reading of a paper on the "Manufacture of Gauges" (see ENGINEERING, vol. ciii, page 85). In the course of his reply to the discussion of the paper in question, Mr. A. G. Cooke, one of the authors, said "it was all very well to construct a perfect screw thread in the cutting, but what would take place," he asked, "during hardening?" This difficulty appears to have been solved by the Westminster Electrical Testing Laboratory, York Mansion, York-street, Westminster, who have had in operation for the last eighteen months a small installation of the Wild-Barfield patent process, which has been utilised during that time almost exclusively for the hardening of inspection screw gauges for the Ministry of Munitions; the gauges require practically no correction after their heating and quenching. In this process the steel is heated very rapidly, and is removed from the crucible furnace to the hardening bath directly it reaches the temperature of decalescence; the treatment of a ¾-in. screw gauge only takes two minutes from start to finish. It is very important that the work should not remain in the furnace for more than a few seconds after it has reached the critical temperature, 780 deg. C., otherwise viscous flow of the material would set in, leading to distortion or uneven swelling. The steel is quenched in a special liquid compound heated to about 200 deg. C. and having a very high vaporising point; the absence of vapour in quenching again makes for absence of distortion. The quenching is sufficiently slow to prevent the formation of martensite, leaving the steel very tough and fairly hard. The electric crucible furnace contains a special liquefied mixture in which the specimen to be heated dips; the crucible is wound with an inner, heating wire. In addition to this, an outside winding is directly connected to a galvanometer. When the steel attains the temperature of decalescence it becomes non-magnetic, a small current is induced in this latter winding, and the galvanometer spot is deflected, when the specimen is at once removed and quenched. The scleroscope hardness of the steel so treated is from 55 to 60, and the correction after treatment of inspection gauges, if any is needed, is very small indeed, and can be carried out quite readily in a simple lathe. The specimens leave the quenching bath quite clean and smooth.

COAL TRANSPORT REORGANISATION SCHEME.—The Board of Trade has issued the following announcement:—In connection with the above scheme the Controller of Coal Mines is considering the requirements of steam raisers in regard to supplies of special coal fuel. Forms have been sent out to steam raisers throughout the country asking for information in regard to the class of coal used, consumption, &c. A considerable number of the forms sent out have not been returned, and steam raisers who have received such forms should note that their requirements in the way of special fuels cannot be considered in the absence of the information called for by the forms, which should be filled in and dispatched to the Controller of Coal Mines immediately. In cases where steam raisers have not received forms it is desirable that they should apply at once to the Controller of Coal Mines, 8, Richmond Terrace, Whitehall, London, S.W. 1.

LITERATURE.

The Principles of Apprentice Training, with special reference to the Engineering Industry. By A. P. M. FLEMING, M.I.E.E., Mem.A.I.E.E., and J. G. PEARCE, B.Sc. (Eng.). Longmans, Green and Co., 39, Paternoster-row, London. [Price 3s. 6d. net.]

IT is of peculiar interest to note that at the present time, when so much praise is being given to the achievements of the workers in the engineering industries directly concerned with the war, there should be a large and growing volume of criticism directed at the conditions which have produced the workers whose exertions during the last two and a half years have resulted in the present magnificent equipment of our Army and Navy and in the provision of much of the essential war material for our Allies. That criticism should exist and grow in the face of the admittedly good record of production during the war, and that it should be largely constructive in character, are facts which indicate not only the necessity for a most searching investigation of the principles upon which present-day education and the training of apprentices are based, but give ground for the hope that from the many remedies proposed a new scheme of training suitable for present and future needs may be speedily evolved.

It is now very generally conceded that the first essential to permanent improvement is a change in the basis and scope of present-day elementary education, a change of which the necessity is recognised and the scope defined in the recently published report of the Scottish Education Reform Committee. In their report the committee propose that definite instruction be given in the virtues of obedience, self-control, temperance, purity and self-respect, as well as in manual work; the formation of literary and scientific societies and the organised development of games are also included in the proposals. While the opinion of educational experts may vary as to the details of any such course as the above, there can be no question as to the necessity of developing the scope of elementary education so as to cover the subjects outlined and so provide a solid groundwork upon which subsequent education and experience may be securely and advantageously built. There is, however, another aspect of the question of training apprentices which calls for immediate action and which provides the authors of the volume now under review with one of their main themes, viz., the education and technical training of apprentices in works.

Broadly speaking, the whole subject of the education of manual workers may be divided into two main parts: (*a*) general education during the period of school attendance previous to commencing work, and (*b*) specialised trade education during apprenticeship, and both these parts are dealt with in an exhaustive manner in the book. In the future means must be found to co-ordinate instruction given in the day schools—particularly during the last two years—with such technical or trade instruction as may be arranged for during apprenticeship, so that the transition from school to work may become a natural continuation and consolidation of education rather than the starting-point for the introduction of subjects involving for the student a new conception of education in its relationship to the actualities of life and work. In "The Principles of Apprentice Training" special attention has been paid to the needs of the engineering industry, and especially to the problems associated with the training of manual workers. The book is divided into four parts, which deal with the economic aspect, primary education, vocational selection and apprentice training respectively, and concludes with a chapter on the course of training provided by the British Westinghouse Company. Time-tables of works classes for apprentices in use at the present time are given as appendices, and along with the author's notes on their working and evolution will be found helpful in extending the scheme.

In the first part of their volume the authors deal with the classification of manual workers under three main groups, viz., skilled workers, specialist or repetition workers, and labourers, and they examine the functions of each class. This examination leads naturally to a definition of the qualities desirable in the individuals composing each class, and so naturally to the fundamental problem of apprentice training, viz., the definition of the educational aim for manual workers collectively and also for the specialised groups already mentioned. The authors rightly believe that the training of each class should be specially considered and arranged to suit the conditions met with in each class in order that maximum efficiency may be developed as a result of the workers becoming acquainted with the principles underlying their work. The economic value of a skilled tradesman as compared with an unskilled labourer, and the gain in economy of production which might reasonably be expected to result from a more intelligent understanding of the processes involved in the production of any article and from a knowledge of the value of the material and tools used, also the loss to the individual and to the community due to the large numbers of youths who begin work in "blind alley" occupations and ultimately go to swell the ranks of unskilled labourers, are clearly pointed out as a preliminary to Part II, which deals with primary education.

The aspects considered are "Characteristics Required by Artisan Workers," "Existing Education in its Relation to Industry," and "Readjustment of Education to meet Industrial Needs," and the importance of this phase of education amply justifies the attention which the authors have devoted to it. The exhaustive summary of the characteristics required for artisan workers which the authors have compiled forms at once a standard by which to judge the results of present-day educational methods and defines the aim of future education for this important class of worker. Judged by this standard the present educational system as a whole falls very far short of the requirements of to-day, and of the number of systems described the American "Gary" system seems perhaps the most hopeful by virtue of its elasticity and the continuity of instruction given.

The recommendations of the Scottish Education Reform Committee give hope of better results in the future, but it should be noted that the committee states that up to the school-leaving age (which it is proposed to raise to 15 years) education should be entirely unspecialised. This view is by no means endorsed by many good judges among men of practical experience in the industrial world, and to such the suggestion of the authors that the latter part of the time spent at the primary school might with advantage be devoted to the study of such subjects as would fit pupils for their coming industrial life will appeal with peculiar force. In support of the latter suggestion it is pointed out that for a very large percentage of manual workers all tuition ceases on leaving the primary school, and it is therefore of advantage to concentrate on such subjects as contribute directly to industrial efficiency; on the other hand the provision of a sound general education for pupils up to 15 years of age would undoubtedly ensure a thoroughly sound basis upon which to develop such technical and trade instruction as may be provided during apprenticeship, as well as providing pupils with that broader outlook which is essential to the satisfactory solution of the industrial problems of the future.

Part III deals with vocational selection—a subject to which but an insignificant amount of attention has been paid in this country—and while informing in respect of the methods tried in America and suggestive as to the importance of the subject in its relation to individual and industrial efficiency, yet the feeling on reaching the end of this part of the volume is that practically no progress has been made to date and the methods at present in use are unreliable. The vast importance of the vocational decision in the case of a youth about to start work is readily admitted, but it will be difficult to persuade industrial firms of the necessity for their undertaking elaborate and at best unreliable investigations which should be carried through on behalf of each lad before he commences his apprenticeship. It is very doubtful if the figures given as to the loss incurred in the starting of unsuitable workers are of any value, for it should be pointed

out that practically all manual workers are engaged directly by the foreman and dismissed directly by him if not suitable, so that office and works losses under this head are very small.

Part IV deals with apprentice training, and is a most useful contribution to the literature on the subject. After all, it is the apprentices of the present day—the skilled workers of the immediate future—who will be first called upon to face the strenuous period of trade rivalry and international competition which all are agreed will follow the war, and it is therefore essential that every effort be made by employers to ensure that they become efficient workers. The subject of apprentice training has therefore a special significance and immediate application, as distinct from the primary education of the schools. Existing methods of industrial training in various countries are described in some detail by the authors, and will be found of great interest to students of the subject. Past and present conditions of apprenticeship are reviewed, and there is much to commend the view expressed that it is unlikely that much progress can be looked for till employers are compelled by statute to provide well-defined means of training and to ensure that apprentices are brought to a definite standard of proficiency such that they could pass an examination before a tribunal of trade experts.

Apprentice training is described as a development of manipulative skill together with the acquisition of knowledge and experience of the materials and tools of the trade, and this description is in the main accurate, although for the higher branches of skilled industry it would be a very decided advantage if apprentices acquired also a sound knowledge of the elementary theoretical principles which underlie their work. The provision of adequate facilities for the acquisition of these essentials forms a most urgent call upon the thought of all progressive employers of labour—particularly in large works where large numbers are employed and where the supervision of apprentices by the regular shop foremen becomes a matter of impossibility.

The methods by which this instruction may best be given so as to ensure the maximum benefit to the apprentices with the minimum disturbance of work in the shops will naturally require to be considered in conjunction with local requirements, but in a general way it seems certain that a portion of the time spent normally in the works will have to be devoted to this special instruction. The establishment of training classes in the works for lads about to commence their apprenticeship in the shops, and the holding of classes during working hours for apprentices actually serving their time, are the two methods discussed by the authors, and of these the latter seems to commend itself specially to them. This conclusion will be very generally concurred in for certain trades, but it is difficult to see how it can be successfully applied in the case of other trades, *e.g.*, apprentice ship platers, rivet boys, &c., but of course the authors do not pretend to put forward a universal scheme, and this remains a problem for future investigators.

The advantages and disadvantages of each system of instruction are carefully set forth, and the ultimate gain to the nation which produces capable, contented workers is emphasised. The inclusion of the complete syllabus of the classes held at the British Westinghouse Company and the explanations which accompany it focus attention upon actual achievement in the arrangement of trade classes and furnish proof, if such be needed, of the immense possibilities in the extension of trade education schemes.

To all who are in any way connected with the development of the manufacturing industries or with the future of education, the plain reasoned statement of the aim and object of apprentice training and of the advantages which would follow the universal adoption of a scheme based upon the principles detailed by the authors will prove of the utmost value, while as a definite, constructive effort at a workable solution to a problem of the first importance in the industrial and social life of the near future the volume is deserving of the highest commendation, and will no doubt receive very careful study.

BOOKS RECEIVED.

Radiodynamics: the Wireless Control of Torpedoes and other Mechanism. By B. F. MIESSNER. London: Crosby Lockwood and Son.

The British Corporation for the Survey and Registry of Shipping, Established 1890. *Rules for Classification and Construction,* 1917. Glasgow: The British Corporation. [Price, issued to subscribers only, individuals and firms, first copy 2*l.* 2*s.*, additional copies 1*l.* 1*s.*; companies, first copy 3*l.* 3*s.*, additional copies 1*l.* 11*s.* 6*d.*]

Second Annual Report of the National Advisory Committee for Aeronautics, together with the Message of the President of the United States Transmitting the Report for the Fiscal Year ended June 30, 1916. Washington: Government Printing Office.

First Annual Report of the State Department of Health of Massachusetts, 1915. *Public Document No.* 34. Boston: Wright and Potter Printing Company.

Electrical Engineering Practice: A Practical Treatise for Civil, Mechanical and Electrical Engineers, with many Tables and Illustrations. By J. W. MEARES, M.Inst.C.E., M.I.E.E., Electrical Adviser to the Government of India, assisted by R. E. NEALE, B.Sc., A.C.G.I. Third edition, revised and enlarged. London: E. and F. N. Spon, Limited; New York: Spon and Chamberlain. [Price 25*s.* net.]

Annual Report of the United States Coast Guard for the Fiscal Year ended June 30, 1916. Washington: Government Printing Office.

What Germany is Fighting for. By Sir CHARLES WALDSTEIN. London: Longmans, Green and Co. [Price 1*s.* 6*d.* net.]

Report on the Working of the Western Australian Government Railways and Tramways for the Year Ended June 30, 1916. Perth: F. W. Simpson, Government Printer.

Science and Industry; a Series of Papers Bearing on Industrial Research. No. 1. *Industrial Research in the United States of America.* By A. P. M. FLEMING, M.I.E.E. London: H.M. Stationery Office. [Price 1*s.* net.]

New Zealand. Mines Statements by the Minister of Mines, including Statistics, Reports relating to Metalliferous Mines and Stone Quarries, &c., &c., for 1915. C—2 *and* C—2A. Wellington: Marcus F. Marks, Government Printer.

Kelly's Directory of the Engineers' and Iron, Metal and Electrical Trades, comprising every Trade and Profession in any way connected with the above Trades throughout England, Scotland and Wales and the Principal Towns in Ireland, the Channel Islands and the Isle of Man, 1917. London: Kelly's Directories, Limited. [Price 36*s.*]

Refractory Materials: A General Discussion Held at the Faraday Society, November 8, 1916. London: The Faraday Society, 82, Victoria-street, S.W. 1. [Price 12*s.* 6*d.*]

Science and Industry: The Place of Cambridge in any Scheme for their Combination. The Rede Lecture, 1917. By Sir RICHARD T. GLAZEBROOK, C.B., M.A., F.R.S. Cambridge: The University Press. [Price 1*s.* 6*d.* net.]

United States Geological Survey. Professional Papers. No. 91. *The Lower Eocene Floras of South-Eastern North America.* By E. W. BERRY. No. 98—I. *A Reconnaissance of the Archean Complex of the Granite Gorge, Grand Canyon, Arizona.* By L. F. NOBLE and J. FRED. HUNTER. No. 98—J. *North American Upper Cretaceous Corals of the Genus Micrabacia.* By L. W. STEPHENSON. No. 98—K. *Some Palæozoic Sections in Arizona and their Correlation.* By FREDERICK LESLIE RANSOME. No. 98—M. *The Catahoula Sandstone and its Flora.* By GEORGE C. MATSON and EDWARD W. BERRY. No. 98—N. *Mechanics of the Panama Canal Slides.* By GEORGE F. BECKER. Washington: Government Printing Office.

Illinois University Bulletin. No. 92. *Engineering Experiment Station. The Tractive Resistance on Curves of a* 28*-ton Electric Car.* By EDWARD C. SCHMIDT and HAROLD H. DUNN. Illinois, U.S.A.: The University; London: Chapman and Hall, Limited. [Price 25 cents.]

United States Geological Survey. Water Supply Papers. No. 360. *Surface Water Supply of the United States,* 1913. *Part X. The Great Basin.* By NATHAN C. GROVER. No. 384. *Surface Water Supply of the United States,* 1914. *Part IV. St. Lawrence River Basin.* By NATHAN C. GROVER. No. 387. *Surface Water Supply of the United States,* 1914. *Part VII. Lower Mississippi River Basin.* NATHAN C. GROVER. No. 395. *Colorado River and Its Utilisation.* By E. C. LA RUE. Washington: Government Printing Office.

CITY OF LONDON MOTOR VOLUNTEER CORPS.—An additional heavy squadron is in course of formation in connection with the 1st/3rd (National Guard) Squadrons of the City of London Motor Volunteer Corps. The class of work covered by the corps, apart from any compulsory requirements in the event of attempted or threatened invasion, includes: (1) Conveyance of troops to working points, for trench digging, field exercises, musketry and other training. (2) Conveyance of arms, stores and equipment. (3) Conveyance of wounded soldiers. (4) Motor transport practice in convoy running and march discipline. There are still a few motor vans and lorries, private motor vans and motor cycles required to complete the establishment of the squadron. Owners who are willing to assist in this branch of the scheme of home defence are invited to communicate with Lieutenant and Acting-Adjutant F. G. Bristow, at the Headquarters, 83, Pall Mall, S.W. 1.

THE LATE PROFESSOR K. BIRKELAND.

PROFESSOR KRISTIAN BIRKELAND, of the University of Kristiania, Norway, whose death we were sorry to see reported from Tokyo, Japan, was best known in connection with his researches and speculations on the cosmic effects of cathode radiations from the sun, especially on auroræ and magnetic storms; and, further, as the originator of the first successful process for the oxidation of atmospheric nitrogen by electric discharges. Though he was not by any means the first systematic observer of auroræ and magnetic storms, the expeditions which the Norwegian Government sent out under his leadership in 1899 and 1900 to Bossekop, near Halde, in the extreme north of Norway, and, in 1902 and 1903, to Iceland, Spitzbergen and Novaja Zemlja (north of Russia), added a great deal to our information on these phenomena, which he summarised in his two large volumes on "The Norwegian Aurora Polaris Expeditions." The influence of the sun as a magnet and of sunspots on planetary phenomena in general had occupied his attention in the first instance. In his experiments he exposed spherical electromagnets, roughly corresponding in the distribution of the magnetic field and the position of the polar axis to our earth, to cathode rays in a vacuum; the financial success of his other work enabled him to conduct these experiments on a large scale, in a vacuum chamber of 70 litres capacity with electric currents requiring a 6-h.p. engine. The side of his "terrella" exposed to cathode rays began to glow, and the stream of rays was deflected, when the terrella was revolved, in two bands which struck the globe near the magnetic poles. It was the study of these electromagnetic phenomena and their effects on the atmosphere which led him to take up the investigation of the oxidation of atmospheric nitrogen by the arc, his flame-arcs—disc discharges in strong magnetic fields—being more than a metre in diameter. The Notodden works were started in 1903. Birkeland was, however, too much the speculative scientist to take a leading part in the technical development of this process, the success of which is perhaps mainly due to his able collaborator, the engineer, Mr. Sam Eyde. The Birkeland-Eyde process later had many rivals, but it maintained its leading position. Owing to failing health, partly due to overwork, no doubt, Birkeland, from 1910, practically retired from technical work, living mostly abroad and devoting himself to the further study of his favourite problems, in which he was joined by his colleagues at the Kristiania University, Professor Störmer, Dr. Vegard and others. In order to study the zodiacal light in particular he spent the first war years in Helwan, Egypt, where he took up his quarters, Uganda and Natal, and then went farther east to Japan, where death overtook him on June 18. He was never a strong man, and he hardly attained his fiftieth year, we believe. Professor Birkeland came over to the British Association meeting at Cambridge in 1904, and attended the International Chemical Congress of 1909 in London. The lecture on nitrogen oxidation which he gave to the Faraday Society—which subsequently elected him a vice-president—in 1906 was one of the most instructive on the subject.

Professor Birkeland had hoped to come over to England this summer, and we are able to add, thanks to the courtesy of the secretary of the Faraday Society, that he intended to lecture to the society again on this occasion.

THE SWISS ORDNANCE DATUM.—Since 1832 altitudes in Switzerland have been referred to the Repère Pierre du Niton. This name indicates two stones, erratic blocks of granite, lying in the harbour of Geneva, the stones emerging at mean water-level one or two metres from the Lake of Geneva. On one of these blocks, the lower one of the two, the Canton engineer, G. H. Dufour, fixed, in 1820, a bronze disc, and this mark was subsequently adopted as ordnance datum. Dufour assumed the level of his mark to be 376.52 m. above the Mediterranean. This value was not accepted, however, deductions based upon the geometrical survey of Henri and Delcros (1804 to 1806) yielding the height 376.64 m. Subsequent determinations, both by levelling and triangulation, all gave values a little above 376 m., but Bourdaloué (1862) found only 374.05 m., and Hilfiker (1902) 373.6 m. When, in 1903, M. Rosenmund introduced the oblique cylinder-projection for the new survey and mapping, the Repère was revised, and the value 373.6 m. was finally adopted, because it rests on level measurements made *via* France, by the shortest route, to the Mediterranean, and on similar measurements made *via* Italy, Austria and Germany, all these being in fair agreement, whilst the trigonometrical determinations differed more strongly. Since 1868 the value 376.86 m. had been in use under the name of the "old horizon." The new value, 373.6 m., was legally sanctioned in December, 1910; there was some confusion at first, however. Since 1917, as Mr. H. Zölly points out in the *Schweizerische Bauzeitung* of July, 7, 1917, all statements as to heights on the hydrographic survey marks and documents, refer to the Repère Pierre du Niton = 373.6 m., which is the new horizon or ordnance datum.

INDUSTRIAL NOTES.

ACCORDING to *The Boiler Maker*, New York, business stands on three legs: capital, labour, management—and the greatest of these is management. Whatever may be the terms used to designate the standards upon which successful business conduct rests, the most important is the policy, or that intangible something termed management. Ample capital and the best of labour, will not produce a profitable business without efficient management. Men start with sufficient capital and the best of prospects, and fail of success, while others begin with the most limited means and forge ahead, due entirely to policy or management. Mechanical skill in industry plays an important part in the management of a business as a whole, and from a shortsighted viewpoint may seem to be the greatest factor, but this is by no means the case. The conduct of business is doing work, executing a contract or disposing of merchandise to produce a profit. Business conduct, to-day, is the greatest game that is being played. It is a matching of brains and mental resources to produce profitable results. The driving force of our great industrial plants is not within these, but at an office which may be a thousand miles away. Ideas, plans and methods concentrated at the office desk operate the railroads, mines, industrial plants and every other profitable business, no matter what its size may be. Business to-day is done with the brain and not with the muscle.

While central station managers in the United States, says *Electrical World*, New York, have been rather restive since war was declared, wondering how they would weather the approaching storm, our Canadian friends have passed through the crisis unscathed. Bereft as some of them have been through the voluntary enlistment of fully 35 per cent. of their staff, and faced also with extraordinary difficulties in regard to coal, they have met the situation manfully, and instead of suffering loss are enjoying a prosperity wholly undreamed of and never before equalled. Almost all the electricity used in Canada is generated from water power, so that the scarcity and high price of fuel are not felt universally in the Dominion; but the demands for energy have been so great that all steam reserve apparatus as well had to be pressed into continuous service. . . . The war has caused Canadians to make a virtue of necessity in a way very much to their credit. Had selective conscription been adopted in Canada from the start, as it has been in the United States, many of the highly trained and dependable men would have been spared to the companies to help to carry the burden. American managers may therefore take heart. With all their anxieties and perplexities our Canadian friends have been equal to every emergency, and, what is most encouraging, they show no sign of overwork; on the contrary, they are unusually cheerful.

We read in *La Métallurgie* that remarkable improvements have been carried out in French industrial establishments. The ingenuity of each and every one has had a free scope. Old traditions have been set aside, and the collective effort of all has yielded new processes particularly interesting. The improvements cover every branch of industry, but are more striking in metallurgy and engineering. Scientific processes are now in constant use in place of empirical methods which hitherto were held in honour. The smallest factory now owns a testing machine, generally a Brinell machine. No steel bar is now taken for the manufacture of a piece of some importance without being submitted first to a Brinell test. The same applies to the heat treatment of steel, and every operative who has charge of quenching and annealing now carries out the work with the aid of an optical or a thermo-electrical pyrometer. Our contemporary expresses the hope that these conditions will continue to rule after the war, as no doubt they will.

The Director of the Department of Labour Statistics, dealing in *The Labour Gazette* with the labour market, states that employment continued good generally in June, with much overtime in many trades. There was, however, some slackness in the cotton trade, and the recent Wool (Restriction of Consumption) Order, 1917, necessitated the working of short time in the woollen and worsted industries except under permit.

The increases in wages and war bonuses reported to the Department as taking effect in June affected over 360,000 workpeople, and resulted in a total increase of nearly 60,000*l.* per week. No decreases were reported. A tendency was again noticeable for various districts to combine in giving uniform advances to employees. Uniform advances were given during June, either nationally or covering large county areas, to woollen and worsted operatives, dyers, bleachers, &c.; tailors, coachmakers, wheelwrights, smiths, &c.; electrical workers, hosiery dyers, bleachers, &c., and gas-meter makers; while uniform rates of wages were arranged for bakers in a large part of the Midlands. Other important increases in June affected building and printing trade operatives and bakers in London, and carters at Liverpool, Manchester and Birmingham.

The number of disputes beginning in June was 41, and the total number of workpeople involved in all disputes in progress was 25,767, as compared with 197,239 in the previous month and 33,823 in June, 1916. The estimated total aggregate duration of all disputes during the month was 192,700 days, as compared with 1,500,000 days in May, 1917 (this being the revised figure including the estimated effect of the engineers' dispute), and 265,000 days in June, 1916.

The average weekly number of vacancies notified to all Employment Exchanges for the four weeks ended June 8, 1917, was 33,636, as compared with 39,536 in the previous four weeks and with 40,263 in the four weeks ended June 9, 1916. The average weekly number of vacancies filled for the same periods was 29,092, 32,183 and 24,934 respectively.

The general level of retail prices of the principal articles of food in the United Kingdom rose about 1 per cent. during June. Prices on June 30, as compared with those on July 1, 1916, showed an average increase of about 28 per cent. No allowance being made for the economies resulting from changes in dietary, prices on June 30, compared with those ruling in July, 1914, showed a general percentage increase of 104. Taking these economies into consideration, the general percentage increase would be 72 instead of 104. No particulars of recent date have been received regarding the movement of retail prices of food in Berlin and Vienna.

Writing in the July Report of the United Society of Boiler Makers and Iron and Steel Shipbuilders, the general secretary states that direct meetings with employers on wages questions are, for the most part, waste of time, as the men are invariably referred to the Committee on Production; the question is being discussed in many quarters as to whether the entrance of the State into industrial problems has been to the men's advantage. He has never been, he adds, a blind supporter of any Government, but with all the shortcomings of this Government, and previous war Governments, he has no hesitation in saying that the part played by the Government in industry during the war has been such that he would give them support in extending the principle of State ownership. He does not want a continuance of compulsory arbitration, nor of the "ticket-of-leave" system. These were self-imposed war restrictions which the men put upon themselves; with the end of the war these must end, but he hopes that the State machinery will be retained for judging the merits of all questions of difference before actual stoppages take place. He has sufficient faith in democracy to believe that through the State there can be constituted fair and impartial courts which would deal with all industrial questions and issue findings which would carry sufficient public opinion behind them to make these awards appeal to both parties and obtain their acceptance without the need of legal compulsion. It is only by the establishment and experience of such machinery that confidence will be restored and industrial war brought to an end.

The Minister of Munitions, in exercise of the powers conferred upon him by the Defence of the Realm Regulations and the Munitions of War Acts, 1915 and 1916, has ordered that all users or consumers of creosote oil, green oil, sharp oil, anthracine oil or other oils with a specific gravity of 1.000 or more, distilled from coal-tar, and all oils with a specific gravity of 0.950 or more distilled from other tars, shall, within 14 days of the date (July 13) of his Order, furnish to the Controller of Mineral Oil Production, M.P.S.3, 8, Northumberland-avenue, London, W.C. 2, the following particulars:—(1) The source or sources from which their present supply is obtained. (2) The quantities of such oils used or consumed by them from January 1, 1917, to June 30, 1917. (3) The quantities of such oils which it is anticipated will be used or consumed by them from July 1, 1917, to December 31, 1917. (4) Full details of the purposes for which such oils have been or are intended to be used or employed.

An award issued last Tuesday by the Committee on Production grants a further advance in wages to all grades of workmen employed by members of the Engineering Employers' Federation. The award, which reads as follows, is given in pursuance of an agreement between the Federation and 46 trade unions connected with the engineering and foundry trades:—

1. The men concerned aged 18 years and over shall receive 3*s.* per full ordinary week as from and including August 1, 1917.

2. To boys and youths and apprentices under 18 years of age there shall be paid 1*s.* 6*d.* per full ordinary week as from August 1, 1917. Boys and youths and apprentices on attaining the age of 18 shall receive a further advance of 1*s.* 6*d.*

3. In the case of piece-workers, premium bonus workers, and other men working on systems of payment by results, the amount is to be paid by the firms at the rate of 3*s.* per full ordinary week over and above the week's earnings of the men concerned, calculated on the present basis.

4. The amounts hereby awarded are to be taken into account in the calculation of payment for overtime or night duty or for work on Sundays and holidays, but they are not otherwise to apply to or affect present time rates, premium bonus rates, or piece-work prices, and are not to be taken into account as part of the time rates for the purpose of fixing new piece-work prices or premium bonus rates.

5. This award shall not apply in those cases in which it has been the practice to regulate the wages of the men concerned by the movements in the wages of men of a similar class employed in trades other than the engineering trade.

6. The amounts hereby awarded are over and above the advances given in the award of March 1 last; they are to be regarded as war advances, intended to assist in meeting the increased cost of living, and are to be recognised as due to and dependent on the existence of the abnormal conditions now prevailing in consequence of the war."

The previous award of the committee, last April, gave the men an advance of 5*s.* per week, making the advance 12*s.* per week over pre-war rates. The present award makes the advance to the men 15*s.* per week.

A conference, presided over by a member of the War Cabinet, was recently held to consider cases which have recently occurred where stoppages of work took place through opposition to awards given by properly constituted arbitrators' courts. Representatives of the Admiralty, the War Office, the Ministry of Munitions and the Ministry of Labour who were present were unanimous in their opinion that such stoppages are indefensible. It was unanimously agreed that no encouragement should be given to stoppages of work arising out of opposition to arbitrators' awards, and that no complaint against the operation of awards should be entertained until a reasonable time had elapsed since the giving of the award, and that no concession should be made to men who have stopped work through opposition to an award already given.

FOREIGN ENGINEERING PROJECTS.

WE give below a few data on a foreign engineering project, taken from *The Board of Trade Journal*. Further information can be obtained from the Department of Commercial Intelligence, Board of Trade, 73, Basinghall-street, London, E.C. 2.

Venezuela.—The *Gaceta Oficial*, Caracas, publishes the text of a contract between the Venezuelan Ministerio de Fomento and Benjamin Gonzalez Maldonado, of Maracaibo, for the working of petroleum, asphalt, &c., deposits in the Altagracia municipality, State of Zulia, the Government leasing the deposits for a period of 25 years. The concessionaire must commence the working of the deposits within three years from the date of the approval of the contract. He will be required to pay annually to the Government one bolivar (9.6*d.*) for each hectare leased, and two bolivars in respect of every metric ton of products produced. All machinery, pipes, instruments and accessories, &c., imported from abroad for the working of the deposits will be exempt from Customs duties. The concessionaire will also have the right to establish railway connections, aerial ropeways, &c., and to construct wharves at the points of shipment. (Hectare = 2.47 acres; metric ton = 2,204.6 lb.)

ECONOMY IN USE OF GAS-COAL, &C.—Various questions of a technical character having recently arisen relating to the supply of gas, the Fuel Research Board have undertaken, at the request of the Board of Trade and other Government Departments concerned, to conduct an investigation and to advise them as to the most suitable composition and quality of gas and the minimum pressure at which it should be generally supplied, having regard to the desirability of economy in the use of coal, the adequate recovery of by-products and the purposes for which coal is now used.

DILATATION OF ARGON AND NEON.—With the aid of his new apparatus for studying the compressibility of gases, Professor A. Leduc (*Comptes Rendus*, June 25, 1917) has determined the dilatation or pressure co-efficient—the increase of pressure resulting when the temperature of the gas is raised, as distinct from the increase of volume on raising the temperature—of the monatomic gases argon and neon. He finds for argon the coefficient $3{,}669 \times 10^{-6}$ and for neon $3{,}664 \times 10^{-6}$. The latter value is very near that assumed for the ideal gas, $3{,}662 \times 10^{-6}$. The internal pressures of the two gases would then be: neon 53×10^{-3} atmosphere and argon 190×10^{-3} atmosphere; the ratio of these two figures, 1 : 3.6, is almost in agreement with the ratio of the squares of the molecular masses, which is 1 : 3.98.

STRESS DETERMINATION IN A FLAT PLATE.

(For Description, see opposite Page.)

Fig. 14.

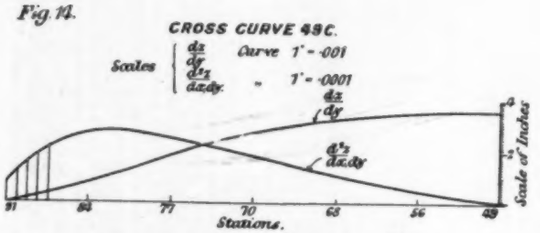


Fig. 15.

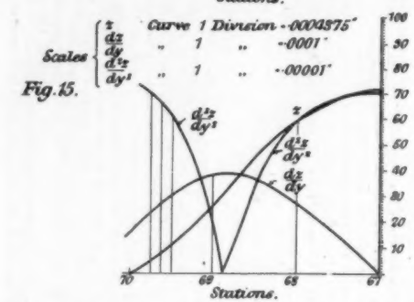


Fig. 16.

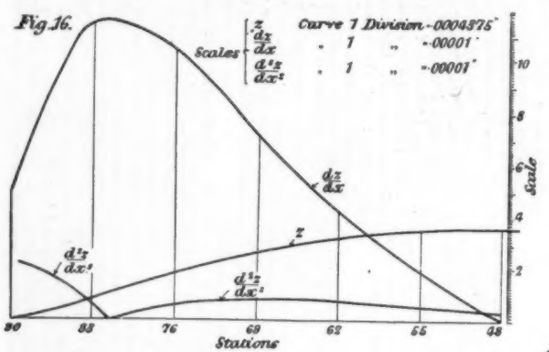


Fig. 17.

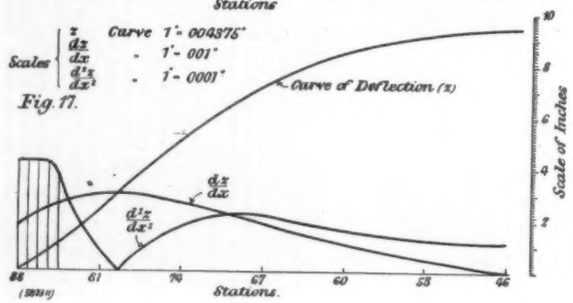


Fig. 18.

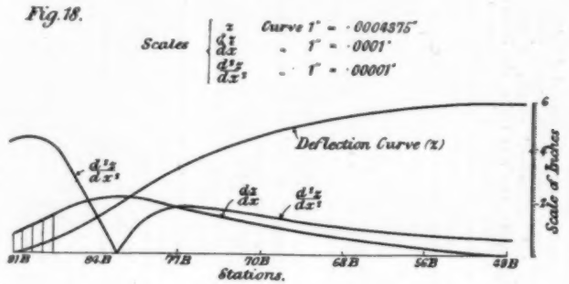


Fig. 19.

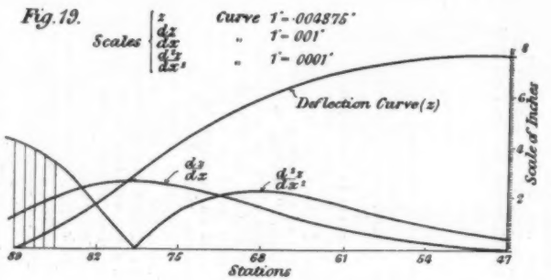


Fig. 20.

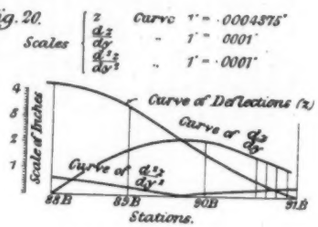


Fig. 21.

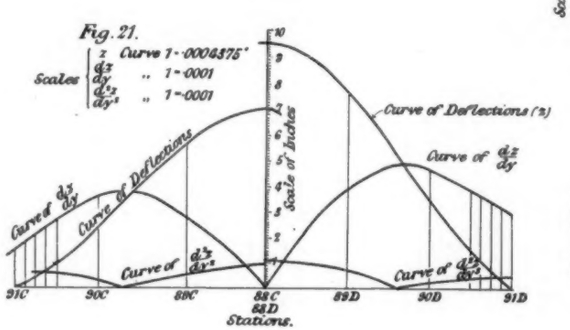


Fig. 22.

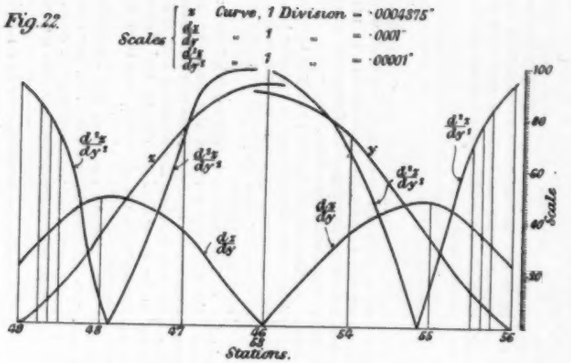


Fig. 23.

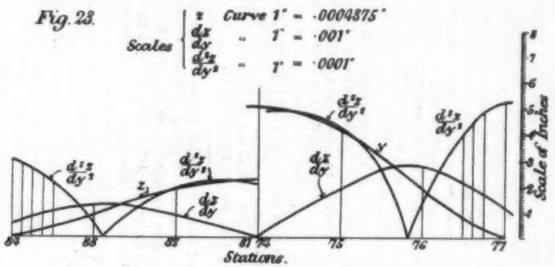


Fig. 24.

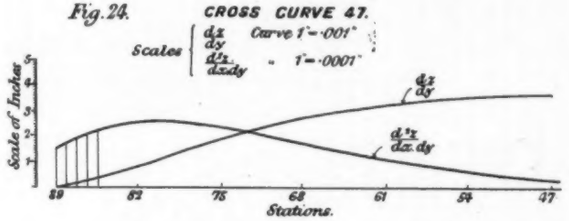
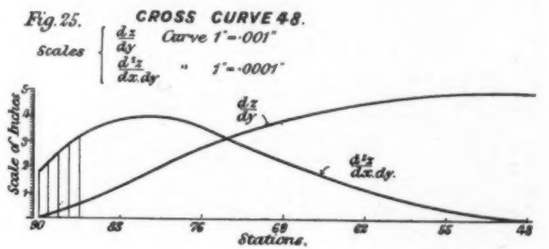


Fig. 25.



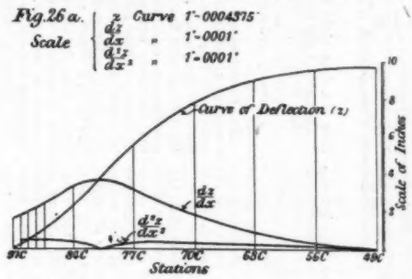
STRESS DETERMINATION IN A FLAT PLATE.*

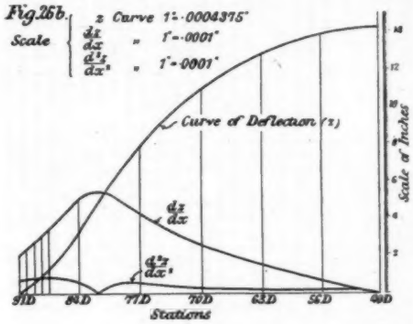
By MR. J. MONTGOMERIE, B.Sc.

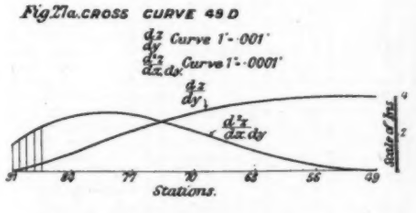
(*Concluded from page* 38.)

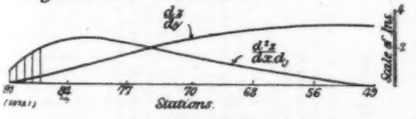
IN order to have an exact record of the form of the plate a large number of additional observations were made along the diagonal and close to the edges. These stations are shown in Fig. 1 (see page 35 *ante*). The deflections being found for all material points on the plate, curves were drawn showing the form of the deflected plate along various lines. These are shown in Figs. 14 to 27, on the opposite and present pages.

These curves of deflection constitute a practical solution of the differential equation of the plate, and the problem now is to find the stress conditions in the plate at any point from a consideration of the curvature









at that point. The principal curvatures at any point in the plate are given by the equations—

$$\frac{1}{r_1} + \frac{1}{r_2} = \frac{d^2z}{dx^2} + \frac{d^2z}{dy^2}$$

$$\frac{1}{r_1 r_2} = \frac{d^2z}{dx^2} \cdot \frac{d^2z}{dy^2} - \left(\frac{d^2z}{dx \,.\, dy}\right)^2$$

This gives a quadratic in $\frac{1}{r}$ as follows :—

$$\frac{1}{r^2} - \frac{1}{r}\left(\frac{d^2z}{dx^2} + \frac{d^2z}{dy^2}\right) + \frac{d^2z}{dx^2} \cdot \frac{d^2z}{dy^2} - \left(\frac{d^2z}{dx\,dy}\right)^2 = 0.$$

Station 46 at the centre of the plate was taken as origin, the line 46–88 the axis of X and the line 46–49 the axis of Y. The values of $\frac{d^2z}{dx^2}$ and $\frac{d^2z}{dy^2}$ may be obtained either by finding an equation to each curve of the form

$$y = A + B x^2 + C x^4 + D x^6 + \&c.$$

or by plotting the curve on a large scale and determining these factors graphically. This latter method was the one chosen, and accordingly the curves were plotted on a large scale, values of the tangents were carefully determined, and these again plotted to represent curves of $\frac{dz}{dx}$, $\frac{dz}{dy}$, $\frac{d^2z}{dx^2}$, $\frac{d^2z}{dy^2}$. The factor $\frac{d^2z}{dx \,.\, dy}$ was obtained in a similar manner by means of cross-curves—values of $\frac{dz}{dy}$ being plotted along the axis of X and differentiated graphically. These curves are also shown in Figs. 14 to 27 inclusive.

To relate the principal radii of curvature to stress take any point P on the upper surface of the plate the co-ordinates of which referred to station 46 as origin are x, y, and let the thickness of the plate be $2t$.

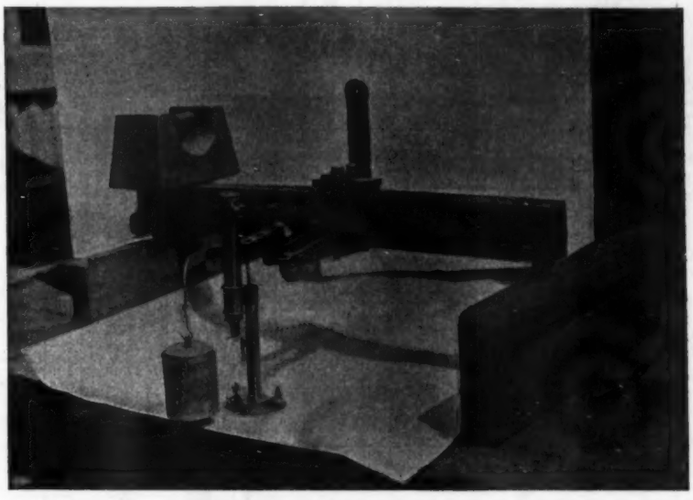


FIG. 28.

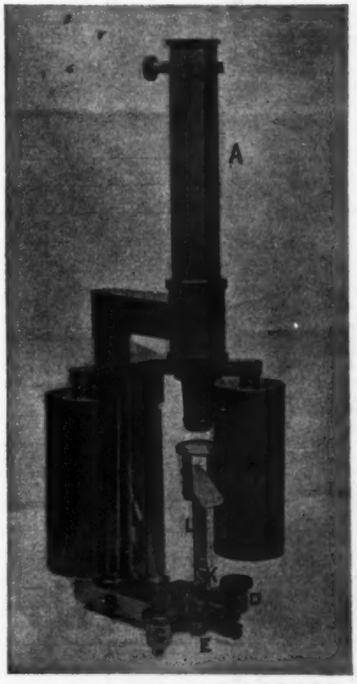


FIG. 28A.

Let a and b be the principal strains at the point P, then

$$a = \frac{t}{r_1}; \; b = \frac{t}{r_2}$$

Let p_1 and p_2 be the principal stresses at P and $\frac{1}{m}$ be Poisson's ratio.

$$a = \frac{t}{r_1} = \frac{p_1}{E} - \frac{p_2}{m\,E} \quad \text{(E is Young's modulus)}$$

$$b = \frac{t}{r_2} = \frac{p_2}{E} - \frac{p_1}{m\,E}$$

from which

$$p_1 = \frac{m\,E\,t}{m^2 - 1}\left(\frac{1}{r_2} + \frac{m}{r_1}\right)$$

$$p_2 = \frac{m\,E\,t}{m^2 - 1}\left(\frac{1}{r_1} + \frac{m}{r_2}\right).$$

The principal stress in a radial direction (= zero) and the strain in this direction are not considered. From these equations the principal stresses, that is, the stresses along the axes drawn parallel to the principal radii of curvature, can be determined for any point on the plate.

It is to be remembered, however, that the reliability of the results obtained from the foregoing depends entirely on the accuracy of the observation and subsequent plotting, and it was considered desirable that some direct observations should be made of the strain conditions existing in the plate. To this end the strain-meter shown in Fig. 28, annexed,* was designed. Fig. 28A, annexed, is another instrument of the same kind, but designed for more general application. The instrument consists in effect of a microscope A (Fig. 28A) carried by a pillar fixed to the base B, which rests on two screws C and D and a spring pin at the back of the base. Attached to the base is a protractor (Fig. 28), and another pin is provided to facilitate centring the instrument over a given point. By adjustment of the screws C and D the instrument is lowered and rests on the spring pin above mentioned and two knife-edges, one of which is permanently attached to the base. The other knife-edge E, shown in Fig. 28A, is formed at the lower end of a lever provided, at its upper extremity, with a glass disc on which is engraved a fine line. The two knife-edges are 0.10 in. in breadth, the blade being slightly rounded and made of hardened steel. At F another knife-edge engages with a prolongation of the base, and the stability of the lever L is secured, when the instrument is not in use, by unscrewing the pin H and permitting contact at K with the small hinged lever attached to the base. The weights M resting on the pillar N constitute a convenient method of weighing the apparatus.

The instrument is used in the following manner. It is first placed in position on the plate and the front screws turned until it rests on the two bottom knife-edges. The pin at H is then screwed down, thus leaving the vertical lever L supported only at E and F. When the plate stretches or is compressed the bottom knife-edges have no motion relative to the plate and the lever L turns about F, causing the engraved line on the disc at the top to traverse the field of the microscope, and the displacement can be measured in divisions of the eyepiece scale. It was found in practice that the contact between the knife-edges and the plate was almost perfect, shock conditions, of course, being absent. Recently, however, a similar instrument has been employed in connection with some experiments on large-size riveted joints at Glasgow, where a certain amount of shock was inseparable from the nature of the experiments, with very satisfactory results. It will be noticed that the instrument is self-contained, and that its readings are not affected by the deflections of the plate. The instrument thus takes account of surface strains only, in the direction of the line joining the centres of the two knife-edges.

The calibration of the instrument was effected by means of an experiment on a steel beam, the physical properties of which had been previously determined. The beam was supported at two points equidistant from the ends. Progressively increasing loads were suspended from the ends, inducing between the supports constant bending moment and therefore circular bending, and the deflections at the centre of the beam were measured microscopically. The actual stretch of the top fibres

* Paper read before the Institution of Naval Architects.

* This instrument was designed by Mr. J. Duncan, of West Ham Technical Institute, and was made by Mr. George McCallum, charge engineer of his staff.

STRESS DETERMINATION IN A FLAT PLATE.

Fig. 29. MEASUREMENT OF STRAIN-¾" PLATE.
Tension, Full Lines. Compression, Dotted Lines.

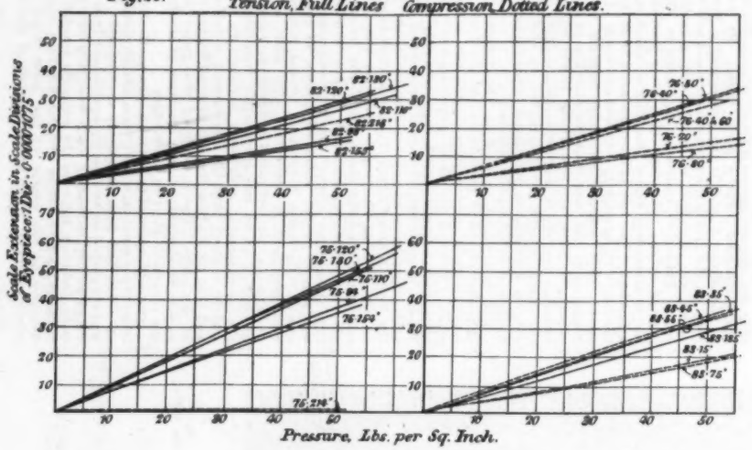


Fig. 30. MEASUREMENT OF STRAIN-¾" PLATE.
Tension, Full Lines. Compression, Dotted Lines.

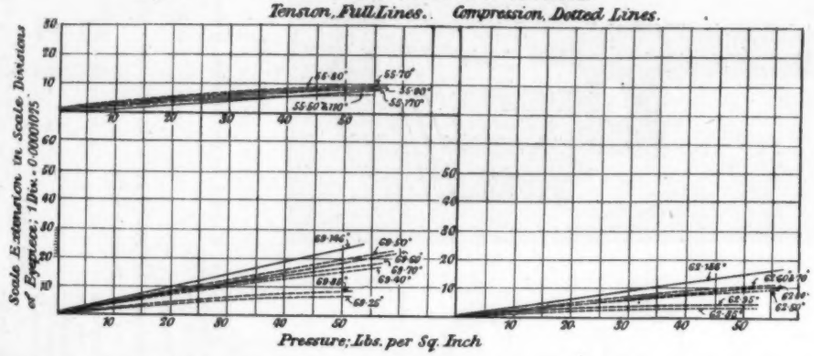


Fig. 31. MEASUREMENT OF STRAIN-¾ PLATE.
Tension, Full Lines. Compression, Dotted Lines.

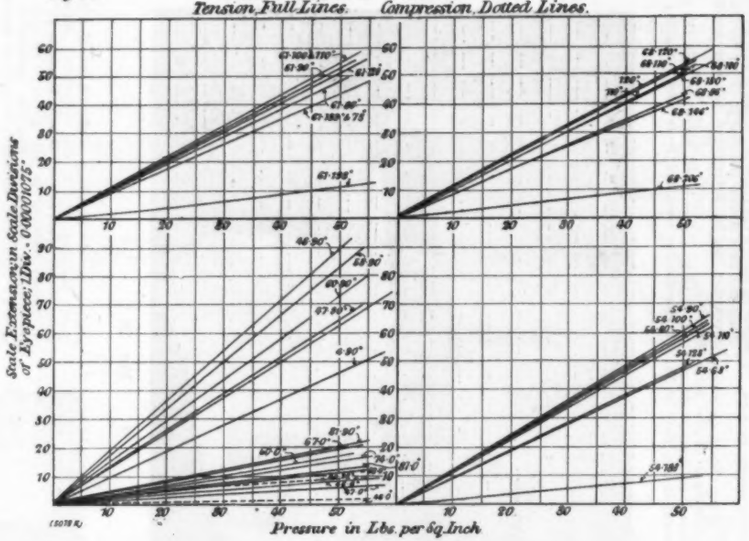
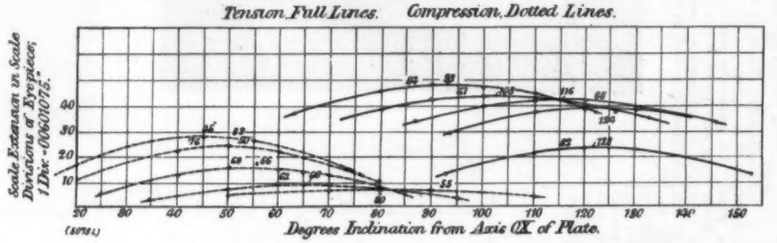


Fig. 32. STRAIN MEASUREMENT AT 40 LBS. PER SQ. IN. TO DETERMINE PRINCIPAL AXIS OF STRAINS FOR EACH STATION.
Tension, Full Lines. Compression, Dotted Lines.



of the beam was found by use of the strain-meter and related to the number of scale divisions observed in the microscope. As the mean of several experiments it was found that one division of the eyepiece scale represented an extension of 0.00001075 in. over the distance between the knife-edges—in this case 2 in.

A very useful result made attainable by an instrument of this kind is the determination, by means of a direct experiment, of Poisson's ratio. Readings are taken with the strain-meter first placed along the beam and then at right angles to it, from which the ratio is at once obtained. The instrument was employed, for the stations 46 to 83 inclusive, to determine the direction of the principal axes of strain and the amount of the strain along these axes. The apparatus was first centred over the station, the centre line being at a definite angle with the axis O X; the pressure was progressively increased to 50 lb. per square inch and observations taken for the successive increments of pressure as in the deflection experiments. The pressure was then removed and the zero reading again taken in all cases. These readings were plotted, and are shown in Figs. 29 to 31, annexed. Curves were then plotted for each station for a pressure of 40 lb. per square inch, the ordinates being the strain in scale divisions and the abscisse the angular deviations of the axis of the instrument from the axis O X. These curves are shown in Fig. 32, annexed, and by drawing a tangent to each curve parallel to the base line the direction of the major principal axis of strain was found. A reading was then taken along this axis and the value plotted at the correct angle in the curve in Fig. 32. The amount of strain along the minor principal axis of strain was also measured.

These strains, when thus determined, were related to stress in the manner described, from which the principal stresses p_1 and p_2, corresponding to the principal strains a and b are

$$p_1 = \frac{m\,E}{m^2-1}(m\,a+b)$$

$$p_2 = \frac{m\,E}{m^2-1}(m\,b+a)$$

where $\frac{1}{m}$ is Poisson's ratio and E is Young's modulus.

The stress conditions of the plate were thus investigated by the two methods, one based on observation of deflection and the other based on direct measurement of strain, and the results in the form of ellipses of stress are shown in Fig. 33, page 77. These results show a very close correspondence, having regard to the nature of the material experimented upon. The stresses along the long diameter of the plate have been plotted in the same diagram, also those along the long and short side parallel to O X and O Y respectively.

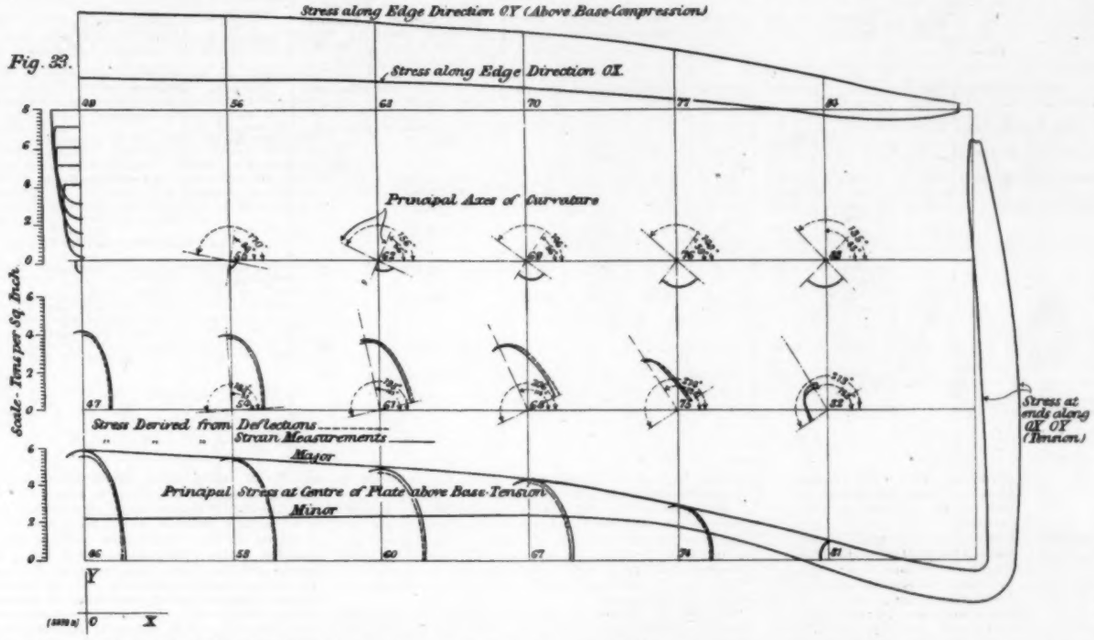
The examination of this diagram shows that the maximum stress does not occur at the end of the short diameter of the plate, but at the centre. The stress at the end of the short diameter, however, approximates in amount very closely to that found at the centre (see Fig. 34, page 77) for the distribution of stress along the line 46–49. The fact appears to be that, even with a plate of the thickness used in this case, the fundamental assumption on which the theory of a beam *encastré* at one end depends is not complied with. That assumption is that the section of the beam in the plane of the wall before bending remains in that plane after bending. This, however reasonable in the case of a deep rigid beam, does not appear to be correct in the case of a relatively flexible plate, and the result is that even with very rigid end fixings the plate takes such a curvature at the edges as permits of the existence of a greatly reduced bending moment and stress at these points.

An examination of the diagram shows that the reasoning of Kirchhoff on which the stresses have been calculated from the deflections is accurate, and also that the empirical rules which have been formulated for dealing with flat plates in the absence of more exact information, and based more or less on the conception that the plate acts as a beam, give stresses considerably in excess of those now found. The best known of these rules are those of Grashof. His rule for the deflection of a rectangular plate gives a deflection at the centre 0.0437 in., which approximates very closely to that found, viz., 0.0410 in. His rule for the stress at the ends of a short diameter of the plate gives, however, a stress 50 per cent. in excess of that found from the foregoing experiments.

To obtain a relation between stress, pressure and thickness of plating, requires a statement and an analysis

STRESS DETERMINATION IN A FLAT PLATE.

Fig. 33.



of the results obtained from the other plates of different thickness, a task which would have expanded this paper beyond practical limits. The results obtained will have a bearing on shipbuilding practice in regard to the additional thickness required for wide spacing of frames, bulkhead stiffeners, &c. It is interesting to note, however, that the stress on shell plating due to water pressure under ordinary circumstances does not appear to be serious. The maximum stress in the plate tested at a pressure of 40 lb. per square inch is 5¼ tons per square inch. Let this be applied to the case of a vessel of dimensions 400 ft. by 52 ft. by 31 ft. The spacing of frames in this vessel is 26 in., and the thickness of the shell plating on the bottom is 0.64 in., and if the frame spacing be increased to 36 in. the thickness of plating becomes 0.74 in. The stress derived from experiment corresponding to a head of water extending to the gunwale would be approximately 1.8 tons per square inch. In determining the stress under the different conditions of frame spacing and thickness of plating, let it be assumed that the stress varies inversely as the thickness of plating and directly as the square of the frame spacing. The stress more probably varies inversely in a ratio approximating to the square of the thickness, but the assumptions made are severe enough to provide for the worst conditions. The following results are obtained :—

Thickness of plating ...	0.73 in.*	0.64 in.	0.74 in.
Distance of supports ...	24 in.*	26 in.	36 in.
Stress (tons per sq. in.)	1.8	2.4	4.0

If the stress varies inversely as the square of the thickness the following results are obtained :—

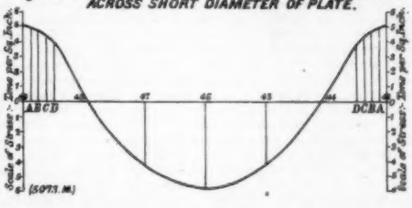
Thickness of plating ...	0.73 in.*	0.64 in.	0.74 in.
Distance between supports	24 in*	26 in.	36 in.
Stress (tons per sq. in.)	1.8	2.7	4.1

* Experimental.

In the first case there is an increment of stress due to the change from 26-in. frame spacing to 36-in. of 1.6 tons per square inch, and in the second case of 1.4 tons per square inch. The modulus of the structure, however, has been increased by 10 per cent., due to to the increase in the thickness of the shell plating, and this implies a corresponding reduction in the structural stresses coming on the vessel, thus nearly neutralising the effect of the increment above referred to. It therefore appears that the shipbuilding practice, as determined by the classification societies, in respect of the increases necessary for widely spaced frames is substantially correct in that it secures an equality between the resultant stresses on the shell plating in the two cases. The effect on the stability of the plating under compressive stress when the frames are more widely spaced need not be considered, as there is no doubt that with the thicknesses usually fitted this element can be disregarded.

COST OF A FERRO-CONCRETE SHIP.—The price of a 1,000-ton ferro-concrete ship at the Fougner yard, in Norway, is stated to be 378,000 kroner, ready for delivery this October; whilst a steel ship of the same dimensions, and to be delivered at equally short notice, could probably not be contracted for at less than about 1,000,000 kroner.

Fig. 34. CURVE SHEWING DISTRIBUTION OF STRESS ACROSS SHORT DIAMETER OF PLATE.



TAR OIL FUEL AND DIESEL ENGINES.*

By GEOFFREY PORTER, A.M.Inst.C.E.

THE honorary secretary of the Diesel Engine Users' Association, Mr. Still, has suggested to me that a paper, or summary, or some form of connected statement dealing with the experience gained up to the present by members of the association in connection with the use of tar oils as fuels for their Diesel engines will be of service at this juncture. The subject was first introduced to us in a practical form by Mr. Charles Day in January, 1916. Since then progress has been made in the problem of adapting our engines for the use of tar oils, and sufficient reliable information is now available to enable a survey to be attempted. True, the experience gained is not very extensive, but it is a useful practice to take the earliest practicable opportunity to study the results of pioneering work, in this instance, pioneering so far as Great Britain is concerned. This is my excuse for appearing before you to-day. With us the adoption of an oil fuel other than residual petroleum oils or shale oils has not recommended itself until comparatively recently owing to the favourable terms on which we have been able to obtain imported residuals. But the force of necessity has compelled us during this period of war to look elsewhere for fuel supplies. Such sources exist in the coal deposits of our own richly endowed land, and they are being brought into utilisation by native talent and skill, which, as often before, have proved themselves in an emergency the equals and more of the best the world can offer. It is not impossible that we are on the eve of freeing ourselves from our former dependence upon other countries for supplies of suitable fuel oils, and I hope the country will arise the stronger from her present difficulties with one more market firmly established within her own boundaries. Members of the association will no doubt be able to take an active part in the development of the use of tar oils, and in so doing perform good service for our beloved country.

In the remarks I have to offer for your consideration, I propose to deal first with tar oil specifications and the quality of the oils offered by distillers; and secondly with facts observed and inferences to be drawn from actual experience.

In Table I (page 78) I have set out the figures obtained by several of our members who have submitted to analysis samples of the tar oils supplied to them. The tests were carried out by qualified analytical chemists. Mr. Day and Mr. Batho have quoted specifications for tar oil which may be regarded as standard. These specifications I incorporate at this point, together with the specification drawn up by the well-known M.A.N. Company of Germany. Comparisons can readily be made by means of the table between the several specifications and the samples tested.

1. Specification of the M.A.N. Company :—

The tar oil must be a distillate of coal tar.

The oil must flow freely at 61 deg. F., and on being cooled down to 46.5 deg. F. and resting in a place undisturbed by vibration no separation shall take place at this temperature within the space of half an hour.

The following constituents shall not be present in quantities greater than the stated percentages :—

	Per cent.
Ash	0.05
Sulphur	1.0

Proportions of water and coke residue not stated.

Per cent. insoluble in xylol	0.2

2. Continental specification for tar oil quoted by Mr. C. Day in his paper on "Tars and Tar Oils as Fuel for Diesel Engines" (January 19, 1916) :—

Tar oils must not contain more than a trace of constituents insoluble in xylol.

The water content should not exceed 1 per cent.

The coke residue should not exceed 3 per cent.

At least 60 per cent. of the oil should be distilled on heating up to 300 deg. C. (572 deg. F.).

The net calorific value should not be less than 15,840 British thermal units per pound.

The open flash-point must not be below 65 deg. C. (143.6 deg. F.).

The oil must be quite fluid at 61 deg. F.

3. Specification of tar oil proposed by Mr. C. Day (January 19, 1916) :—

The tar oil must be a product of the distillation of coal tar. No product that has not undergone distillation must be present.

		Per cent.
Insoluble in xylol	...not more than	2.0
Ash	,, ,,	0.08
Water	,, ,,	2.5
Coking residue	,, ,,	3.0

The oil must be liquid at 60 deg. F. when maintained at that temperature for half an hour.

In case of crystals settling in the transport tank the buyer to be allowed to drain off the liquid portion and to return the solid to the seller.

Mr. Day pointed out that the calorific value of tar oils as determined by numerous tests is not a very variable quantity and suggested that a definite heat value should not be stated in the specification.

4. Mr. Batho put forward a specification for tar oils at the Diesel Engine Users' Association meeting of February 23, 1916, in the course of remarks he then made, as follows :—

Specific gravity	Between 1.0 and 1.1.
Viscosity ...	Generally 2 deg. Engler (all coal tar oils are very fluid).
Flash-point ...	100 deg. to 130 deg. F.
Colour ...	Tar oils are as a rule dark to almost black. One drop on white paper should show no black residue as is the case

* Paper read before the Diesel Engine Users' Association, on Thursday, 24th May, 1917.

TABLE I.—SPECIFICATIONS FOR TAR OILS AND RESULTS OF TESTS OF TAR OILS SUPPLIED TO MEMBERS OF THE ASSOCIATION.

—	—	Flash-Point.	Specific Gravity.	Water Content.	Sulphur Content.	Ash Content.	Coke Content.	Tar Acids.	Calorific Value, B.T.U. per Lb. G.—Gross Value. N.—Net Value.	Content Insoluble in Xylol.	Distilling below 610 deg. F.	Loss at 220 deg. F.	Viscosity.	Setting-Point, &c.
1	M.A.N. Company's Specification	Deg. F.	—	Per cent.	Per cent. below 1	Per cent. 0.05	Per cent.	Per cent.	N.—16,000	Per cent. 0.2	Per cent.	Per cent.	—	46.5 deg. F.
2	Continental Specification (Mr. C. Day)	143.6	—	1.0 (max.)	—	—	3.0 (max.)	—	N.—15,840 (min.)	a trace	60 per cent. at 572 deg. F.	—	—	Fluid at 61 deg. F.
3	Mr. C. Day (Jan. 19, 1916)	—	—	2.5	—	0.08	3.0	—	—	2.0 (max.)	—	—	—	Fluid at 60 deg. F. for ½ hour.
4	Mr. Batho (Feb. 23, 1916)	100.0 to 130.0	1.0 to 1.1	1.0 (max.)	0.5 to 1.0	1.0 (max.)	—	—	N.—15,800 to 16,500	—	—	—	2 deg. Engler.	—
A	Test of oil supplied ..	190.4	1.039 at 60 deg.F.	0.4	0.58	0.03	—	10.0	N.—16,234	—	65.6	—	—	—
B	,, ,, ..	169.0	1.033 at 70 deg. F.	0.2	—	Nil	2.61	14.0	N.—16,475	—	—	—	103 Redwood at 70 deg. F.	—
C 1	,, ,, ..	—	1.057 at 60 deg. F.	3.70	1.99	0.21	4.77	Nil	N.—16,484	0.89	72.4 per cent. by weight	16.10	103 Redwood	—
C 2	,, ,, ..	197.0 (open)	1.0525 at 60 deg. F.	2.9	2.12	0.02	8.39	trace	N.—16,532	0.48	72.10	14.8	at 32 deg. F. —121 secs. at 70 deg. F. —70 secs.	—
D	,, ,, ..	—	1.0326	0.83	0.73	0.07	—	—	G.—17,080	—	—	—	—	—
E 1	,, ,, ..	—	1.065 at 61 deg. F.	1.00	0.5	0.2	3.0	—	N.—16,637	—	—	—	—	Hydrogen 6.8 per cent., oxygen and nitrogen 2.4 per cent., carbon 90.1 per cent.
E 2	,, ,, ..	—	—	11.0	—	—	—	—	N.—15,724	—	—	—	—	—

with tar. This black residue means a large percentage of free carbon or other tar ingredients.

Lower calorific value ... Between 15,800 and 16,500 British thermal units per 1 lb.

Ash ... ... Should not exceed 1 per cent. (unburnt residue of tar oil is mostly harmless).

Water ... ... Should not exceed 1 per cent.

Sulphur ... 0.5 per cent. to 1 per cent.

Pitch ... ... If the tar oil contains a high percentage of residue which only begins to vaporise at 400 deg. C., then the same results can be expected as with tar; that is to say, one must anticipate a considerable amount of dirt in the engine and the exhaust valves will require frequent cleaning and grinding in.

The notes attached to the above enhance the value of the specification.

I propose now to compare the analyses A to E 2 in Table I with these specifications.

To the best of my knowledge the samples tested were derived from English sources. Speaking generally, the tar oils supplied agree in substance fairly closely with the specifications. I must point out that it is desirable, at the present moment, not to draw a specification for tar oil too tightly. So far as the demand for these oils in connection with Diesel engines is concerned it is a new one in this country. Tar oils for our purpose are not yet standardised, and it is too early as yet to draw hard and fast lines. The products we are obtaining are, in general, giving satisfactory results. The specific gravities vary a good deal among themselves, but they all lie within the limits mentioned by Mr. Batho. E 1 is 3.1 per cent. heavier than D, the least heavy of the series. I have not heard that any difficulties have arisen that are attributed to specific gravity. The flash-points have been ascertained in only three instances; they are taken at different temperatures and are perhaps high, especially that of C.

Samples C and C 2 are in excess of the others in respect of water, in fact, a great deal in excess. E 2 is so extraordinarily high that I think some special circumstance must account for the figure, 11 per cent. I understand that the water content is a difficult one to determine, chiefly because of the peculiar property of water to collect in pockets in oil. Hence a sample may not be representative of the bulk, and *vice versa*. Further, the oil enters into ebullition at 212 deg. F. Tests of water content must therefore be accepted with caution. Owing to the high specific gravity of the tar oil, water is not so troublesome in ordinary engine operation, as it rises to the top of the service tanks. With petroleum residual oil the reverse is the case and water occasionally will stop an engine if the attendant is not careful. That water is a useless addition to a fuel oil requires no argument.

The sulphur contents in these samples are all good, the C samples showing the greatest proportion. Otherwise the sulphur percentages are within the specified limits. The influence of sulphur in Diesel engines was very fully described by Dr. E. Graeffe, of Dresden, and reported at an association meeting in 1915. Dr. Graeffe treated the matter exhaustively, as will be seen by members if they care to look up his communication. Nevertheless it is desirable to keep the sulphur content low.

Except for C 1 and E 1 the ash contents of the samples are tolerably close to the M.A.N. limit, but all are well below the maximum quoted by Mr. Batho.

The coke residues of the four samples are near to the specified limits for B and E 1, but appear to be rather excessive for C 1 and C 2. This item must be carefully studied. I have seen tests which indicated a coke content as high as 26 per cent. Such an oil would be unsuitable for use in a Diesel engine.

As suggested by Mr. Day the calorific values agree fairly closely with one another and with the specifications. The *lower* calorific value is, of course, the important one for our consideration. In the case of D the lower value is approximately 16,430 British thermal units per 1 lb. Below a value of about 15,800 the oil is unsuitable for use in Diesel engines.

Only in the case of C 1 and C 2 have the constituents insoluble in xylol been obtained. This is a pity, for the production of these insoluble substances is an important matter. It is essential to reduce the amount of suspended solids in the oil to an absolute minimum, for they form nuclei for the formation of deposits which carbonise and give rise to difficulties in working an engine. The figure ascertained for the C samples is fair—much lower than the percentage put forward as permissible by Mr. Day. They are, however, very excessive when compared with the M.A.N. company's requirements. The C 1 and C 2 samples differ in themselves by 85.4 per cent. Evidently the German company insists on a nearly perfect exclusion of insolubles, in which requirement it must be conceded they are on firm ground. (Many of us, no doubt, do not know what "xylol" is; it is described as dimethyl benzol and has the chemical formula C_8H_{10}; its boiling-point is 139 deg.) The percentage of distillation below 610 deg. F. has been determined only for A, C 1 and C 2, and the samples conform fairly well with specification No. 2.

The carbon, hydrogen, oxygen and nitrogen percentages have been determined in one instance only, E 1; these particulars are of interest in connection with the heating value of an oil; they are necessary when it is required to work out a heat balance sheet from engine trial results. Mr. Harold Moore published some useful analyses in a paper read by him on February 26, 1916, before the Manchester Association of Engineers; the tables will repay study. It is a somewhat remarkable fact that the results shown by the test of the sample E 1 are in every respect identical with Mr. Moore's figures for a horizontal retort tar oil. If the origin of the samples should be the same the accuracy of the distillation is remarkable. E 2 represents a second evaluation of the calorific value of an oil obtained from the same source. It will be seen that the figures obtained differ considerably from those stated under E 1; the water content is very excessive. Whether this result is due to the "pocketing" of water in the sample and is therefore not truly representative of the bulk I am unable to say, but the purchaser has not intimated to me that worse results were obtained in the use of the later oil than he found in the case of the earlier deliveries.

It is a matter for regret that none of the tests contain the determination of the setting-point, for it is intimately concerned with the phenomenon of "crystallisation."

The M.A.N. specification (1) requires the oil to remain liquid at a temperature of 46.5 deg. F. when it is undisturbed for a period of half an hour, and to be fully liquid at 61 deg. F. Mr. Day's specification concurs. Those of us who have been using tar oils for the first time during a particularly cold winter have learned by experience that this desideratum is not merely a chemist's fad. At a temperature below 45 deg. F. crystallisation is heavy. In one instance I found fully 30 per cent. of the contents of a tank of oil (out of doors), containing 11 tons, to be extremely thick. It could not be pumped at all. Heating a gallon drawn out in a pail dissolved the crystals, but to heat the whole tank was impracticable. Finally the difficulty was overcome by violently agitating the bulk, when the oil became fluid. This method was adopted throughout the winter as occasion required; it cost nothing, and was quite successful. I do not know definitely if crystallisation is accentuated by an excessive proportion of naphthalene in the oil. All tar oils, I am informed, contain naphthalene in greater or less degree. It appears to an engineer obvious that the formation of naphthalene crystals on cooling may contribute largely to the crystallisation of the tar oil by providing a large number of nuclei about which films of oil concentrate until a semi-solid condition is attained. I should say that this theory is pure speculation on my part, for I am in no sense a chemist, and I have had no opportunity of taking up the naphthalene question seriously with a qualified man. Naphthalene itself has a high calorific value, and has been used successfully in an internal-combustion engine as the sole fuel. Moreover, a creosote oil containing a higher percentage of naphthalene when mixed with a very viscous mineral oil (residual) has a lower viscosity than either of its constituents. I am indebted to Mr. G. Nevill Huntly, B.Sc., F.I.C., for this interesting piece of information. Naphthalene, then, whatever its disadvantageous properties may be, has good and useful characteristics. From our experience up to the present one fact at any rate emerges, i.e., that tar oil is better stored under cover in a moderately high temperature than in the open. I have, fortunately, not been troubled with the formation of crystals in railway tank wagons. Possibly the heavy vibration in transit is sufficient to maintain the oil in a continuous state of agitation. There is obviously a great deal to learn about tar oils for our purpose, and in this we can hope for the co-operation of the skilled analytical chemist. The training and experience of the engineer are not such as to fit him, as a general rule, for the solution of physical problems such as are met with in examining oils. The engineer (in his own opinion at least) rules the world nowadays; but I am not sure that the analytical chemist does not actually sit in the heart of things.

(*To be continued.*)

THE RHENISH COAL AND SHIPPING COMPANY.—This company, whose offices are at Mühlheim-Ruhr, has increased its capital, owing to new regulations for coal-trading companies, from 17,660,000 marks to 31,510,000 marks. The company is entitled to erect establishments of all kinds likely to further its legitimate ends and to participate in other similar undertakings.

SALT, BROMINE AND CALCIUM CHLORIDE IN THE UNITED STATES, 1915.—From "Mineral Resources of the United States" we see that the marketed production of salt in the United States in 1915 had risen to 38,231,496 barrels, valued at 11,747,686 dols., the figures representing increases of 10 per cent. and 15 per cent. in quantity and value over the figures of 1914. The figures include Hawaii and Porto Rico. The United States, Mr. W. C. Phalen, the writer of this section, points out, furnished 99 per cent. of the salt consumed by the people of the country, and as the supplies seem inexhaustible, the country might supply the world. The capacity of the existing plants is 25 per cent. in excess of the actual output. Most of the salt is obtained from artificial brine, but rock salt and natural brine are also utilised, the evaporation processes used being: solar evaporation, direct heat evaporation, steam evaporation in jacketed kettles or in graniers (in these the salt is not touched by hand at all, and great ingenuity has been displayed in their improvement) and in vacuum pans. Salt of all grades is made. Solar-heat evaporation is chiefly in use in California. The most important salt-producing State is Michigan, where both rock salt and natural brine occur. The latter occurrence, in the Saginaw Valley, is quite distinct from the rock salt, and the brine contains both bromine and calcium chloride; owing to the increased demand for bromine, old bromine works which had been shut down have been reopened. Bromine salts are also found in the Ohio Valley and in Western Virginia, from which bromine has been exported for many years. The total bromine salt production of the years 1913, 1914 and 1915, was 572,400 lb., 576,231 lb. and 855,857 lb., valued at 115,436 dols., 203,094 dols. and 856,307 dols. The calcium chloride production is unimportant. As regards common salt the State of New York ranks next to Michigan, the further order being Ohio, Kansas, Louisiana, California.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

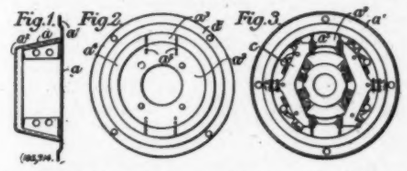
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

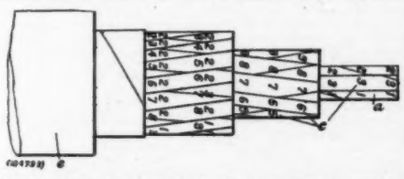
ELECTRICAL APPARATUS.

105,714. A. H. Midgley and C. A. Vandervell and Company, Limited, Acton Vale. Dynamo Electric Machines. (10 *Figs.*) October 19, 1916.—This invention relates more particularly to the construction of the end-shields of small-size dynamos. *a* is the commutator end-shield, made of one stamping, and comprises an outwardly extending flange a^1 by which the shield *a* is attached to the yoke of the dynamo, and an inwardly extending flange a^2 for receiving the bearing and two connecting pieces a^3



by which the flanges a^1, a^2, are connected together, the remaining circumferential parts a^1 of the shield being entirely open. The connecting pieces a^3 are formed with lugs a^5 extending on either side inwardly, each two opposite lugs being connected together by a pair of brush-holder brackets *c*, which also act as strengthening members of the commutator end-shield. The pulley end-shield comprises a shield provided with a flange by which the shield is attached to the yoke of the dynamo and with an opening for receiving the bearing. (*Accepted May* 2, 1917.)

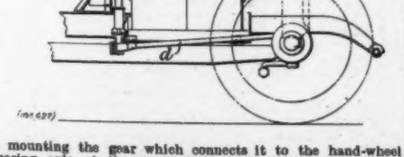
104,793. J. O. Callender, Woking, and Callender's Cable and Construction Company, Limited, London. Electric Cables. (2 *Figs.*) May 23, 1916.—This invention relates to electric cables in which a number of individual conductors or cores, each one insulated from the other, are wormed or laid up together and enclosed in one outside covering. The object of the invention is to provide improved means whereby each individual conductor can be identified (when the complete cable is opened out at any point in its length), these means consisting of the provision of numbers or letters which are impressed



upon the outside of each insulated conductor or core at convenient intervals, and on any or all sides of same, as considered necessary, before the insulated conductors are laid up and wormed together. *a* represents the individual insulated cores of the multicore cable *e*, each complete core having an electric conductor; *e* represents the impressed identification marks on the outside of each individual core. When the individual cores are each appropriately impressed they are laid up and wormed together, and the cable may be completed by the provision of a sheath of lead or other suitable material, or in any other suitable manner. (*Sealed.*)

MOTOR ROAD VEHICLES.

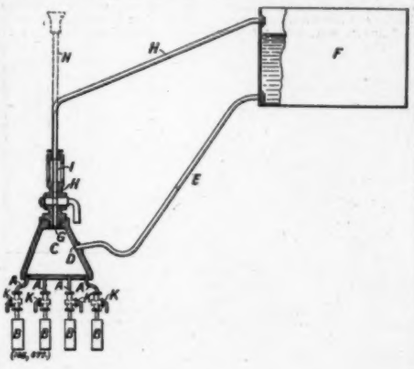
104,427. L. H. Pomeroy and Vauxhall Motors, Limited, Luton. Motor Vehicles. (4 *Figs.*) May 26, 1916.—This invention relates to the steering control of motor vehicles, and is specially applicable where V-type engines, situated between the front wheels, driving the usual fore-and-aft propeller shaft, are used for propulsion. The invention consists in arranging the steering lever to pivot on a vertical axis disposed in proximity to the dashboard, and



in mounting the gear which connects it to the hand-wheel steering axle at the upper end of the shaft carrying this lever. Mounted on the engine side of the dashboard is an upright shaft *a*. This upright shaft *a* is conveniently disposed behind one group of cylinders of the V-engine. At the lower end of this shaft is mounted the main steering lever by which power is transmitted through the connecting-rod *d* to the stub-axle lever of one of the front wheels. On the other end of the vertical shaft *a*, above the top of the cylinders, is mounted a toothed pinion or segment, the teeth of which are adapted to mesh with the teeth secured or formed on the outside of a nut-like member which is threaded upon a threaded portion of the lower end of the hollow shaft *i* carrying the hand-wheel *k* for steering. (*Sealed.*)

PUMPS.

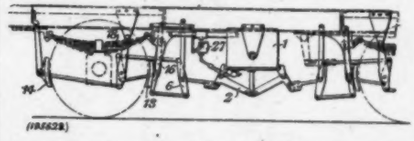
105,677. Sir W. G. Armstrong, Whitworth and Company, Limited, and L. J. Le Mesurier, Newcastle-upon-Tyne. Pumping Systems. (1 *Fig.*) June 29, 1916.—This invention relates to the detection of the defective working of a pump. According to this invention, a vessel is connected to the suction pipe or pipes of a pump or set of pumps, and is supplied with fluid through an inlet in its side or bottom, whilst an outlet is provided at the top leading to a gauge glass. If any air is pumped into the vessel, the outlet allows of its escape, and the escaping air can be seen by observing the gauge glass. A, A, A, A are the suction pipes of a number of pumps B, B, B, B connected to the bottom of a conical vessel C, which has an inlet D at its side connected by a pipe E to a tank F located at a higher level. At the



top of the vessel C is an outlet G, from which extends a pipe H leading to a gauge glass I; the pipe H may lead back to the top of the tank F, or may be extended upwards as shown in dotted lines. Each of the suction pipes A of the pumps B is provided with a cock K. In this arrangement, if a pump fails air is blown back through its suction pipe A to the vessel C, from whence it can escape through the vent pipe H and gauge glass I without interfering with the supply of liquid through the pipe E. The passage of the air through the gauge glass I can be easily observed, and the faulty pump can be readily located by use of the cocks K, by means of which each pump in succession can be tried without interfering with the flow of liquid from the tank F to the remaining pumps. (*Accepted May* 2, 1917.)

RAILWAYS AND TRAMWAYS.

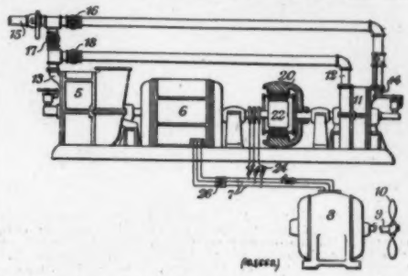
105,628. E. S. Luard, London. Brake Apparatus. (4 *Figs.*) April 20, 1916.—This invention relates to brake apparatus for railway vehicles, and has for its object to provide apparatus in which the effective brake power varies in strength as the load varies, the brake apparatus being sufficiently powerful to efficiently brake the vehicle with any load up to the maximum, but so constructed that it will not cause skidding of the wheels when the vehicle is empty or only lightly loaded. The invention principally consists in the provision of means, in connection with the brake rigging, which, after the brake blocks have been moved into contact with the wheel treads by the application of brake-operating power to the rigging, are operated by the power developed in the brake cylinder to cause the weight of the vehicle when unloaded, or vehicle and its load when loaded, to become the power factor for holding the brake blocks to the wheels, so that the brakes are applied to the wheels in a manner or strength proportional to the load of the vehicle. The said means comprise a lever 16 connected to a vehicle-bearing spring 18 and to a sway beam 6 which is also connected to the brake blocks 13, 14, and to a power crank or lever 2 of the brake apparatus, the



arrangement being such that when the brakes are applied the brake power is distributed by the beam 6, first to the blocks 13, 14, and then to the lever 16, so that the latter lifts the vehicle, the weight of which, with whatever load it may contain is, through the said levers, then put upon the blocks, and becomes the "power" holding them to the wheel treads. A further feature of the invention consists in the provision, in fluid pressure or vacuum brake apparatus, of means whereby, when a strength of brake application proportional to the load has been obtained, the action of the power on the brake piston in the cylinder is rendered ineffective for giving further movement in or increasing the power obtaining in the rigging, and the expenditure of unnecessary power avoided, this result being effected without reducing or destroying the potential power in the cylinder or cutting off power from the piston, the said means comprising a valve device 27 connected with the cylinder 1 on the atmospheric side of the piston, whether such piston be that of fluid pressure or a vacuum brake cylinder, and controlling the connection of such side of the piston with the atmosphere. (*Accepted May* 2, 1917.)

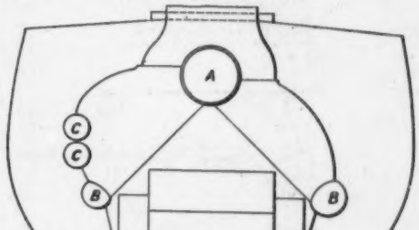
SHIPS AND NAUTICAL APPLIANCES.

105,660. The British Thomson-Houston Company, Limited, London (*General Electric Company, Schenectady, U.S.A.*). **Turbo-Electric Ship Propulsion.** (2 *Figs.*) June 5, 1916.—The invention relates to systems of ship propulsion in which the ship's propellers are driven by electric motors. 5 diagrammatically represents a main elastic fluid turbine designed for high efficiency as a high-speed pressure machine and adapted for economic operation at lower speeds when supplied with elastic fluid of lower pressure. The main turbine is directly coupled to an alternating-current generator 6 electrically connected by leads 7 to a polyphase induction motor 8, the rotor of which is mounted on a propeller shaft 9 carrying a propeller 10. An auxiliary or cruising turbine 11, designed for high efficiency as a high-speed high-pressure machine, has its exhaust pipe 12 connected to the admission pipe 13 of the turbine 5. The admission pipe 14 of the turbine 11 is connected to the main supply pipe 15. The pipe 15 is also in communication with the admission pipe 13 of the turbine 5. When the valves 16 and 18 are closed and valve 17 open, the turbine 5 receives steam directly from the boilers. Under this condition of operation the turbine 5 will run at high speeds with high efficiency, and variations of the ship's speed over the high-speed range can be obtained by varying the steam admission to the turbine, whereby the speed of the turbine, and accordingly the frequency of the alternating current energy delivered to the propeller-driving induction motors, are correspondingly varied. The auxiliary turbine 11 is directly coupled to the rotatably mounted field magnet structure 20 of an induction generator. The armature 22 is mounted on the same shaft as the rotors of the turbine 5 and generator 6. The armature winding of the induction generator 20 is electrically connected to slip rings, which are, in turn, adapted to be electrically connected to the leads 7. The operation of the system is as follows:—For the higher range



of speeds the switch 24 is open and switch 26 is closed, and valves 16 and 18 are closed, while valve 17 is open. The turbine 5 and generator 6 thus run at their respective high speeds, and the frequency of the alternating-current energy delivered by the generator 6 to the induction motor 8 is such as to produce the proper propeller speed for high-speed navigation of the ship. During this condition of operation the auxiliary turbine 11 is operatively inactive and the armature 22 of the induction generator 20 rotates idly. Speed variations of the propeller, and hence of the ship, for this condition of operation, can be obtained by controlling the admission of steam to the turbine 5. For navigation at the lower range of speeds, such as her cruising speeds, an arrangement of the apparatus is made by which the operating speed of the main turbine 5 is materially reduced, resulting in a corresponding reduction in the frequency of the alternating-current energy supplied by the generator 6 to the motor 8, and hence a reduction in the speed of this motor. This condition of operation is obtained by closing the switch 24 and valve 17, and opening valves 16 and 18, whereby the synchronous and induction machines are electrically connected together and high-pressure steam is admitted directly to the cruising turbine 11, while the main turbine 5 operates with exhaust steam received from the cruising turbine. (*Accepted May* 2, 1917.)

105,727. H. E. Yarrow, Scotstoun, Glasgow. Fuel Storage. (2 *Figs.*) December 8, 1916. In certain classes of vessels using oil fuel, more particularly destroyers, it is important to increase the storage capacity for the oil beyond that usually provided. In addition to the tanks usually provided, other oil tanks may be placed amidships underneath the boilers throughout the stokehold compartments. In order, however, to prevent the oil tanks underneath the boilers from being raised to too high a temperature by the heat radiated from the brick pans at the bottom of the furnaces, according to the invention, a grid of small

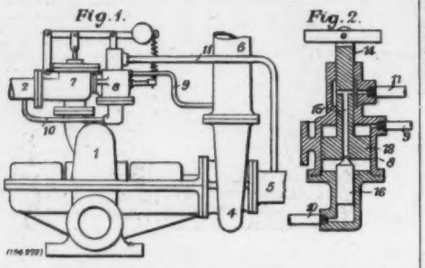


tubes through which water circulates is placed between a brick pan and the tank below it. A is a steam drum, B water drums, C superheater tubes, D are oil tanks underneath the boilers, E is a grid formed of small tubes, through which water circulates. The grid is placed between the bottom of the brick pan and the oil tanks, and may extend across the full width of the tanks, or only across the central part of this width. The water tubes E are fitted into headers. The water supply to the grid may either be the feed suction, in which case the feed water would be slightly heated, or an independent supply of water may be caused to circulate through the grid by a pump. (*Accepted May* 2, 1917.)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

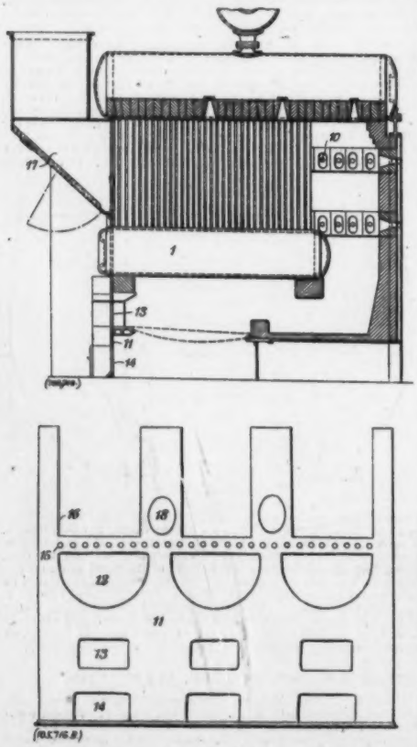
104,372. The British Thomson-Houston Company, Limited, London, and R. F. Halliwell, Rugby. Feed Pump Pressure Regulators. (2 *Figs.*) February 28, 1916.—This invention relates to regulators for controlling the amount of water delivered to a boiler by a pump by a prime mover. The invention consists in a feed-pump pressure regulator comprising a cylinder provided with a piston and a piston rod, through both of which a passage is formed, and a movable plunger operated by the steam pressure and adapted to act as a valve to close the said passage. 1 is a steam turbine driving a centrifugal pump 4. The admission of steam to the turbine is governed by a throttle valve 7 actuated by an operating motor 8, connection being made to the water delivery main 6 through the pipe 9, and to the steam supply main 2 through the pipe 10. Waste water from the operating

cylinder is led through the pipe 11 connected to the suction side of the pump 4. The operating motor consists of a cylinder fitted with a piston 13 having a piston rod 14 connected to the gear actuating the throttle valve 7. Extending up the centre of the piston rod is a passage 15 in communication with the waste water outlet 11. The lower end of this passage can be closed by the end of a plunger 16. Water under the delivery main pressure is admitted through pipe 9 into the space above the piston 13. The space below the plunger 16 is in communication with the steam pressure through the pipe 10. It will be seen that in order to obtain equilibrium the pressure above the piston 13 must be to some extent higher than the pressure beneath the piston, depending on the area of the piston rod 14, also it will be seen that the pressure beneath the piston 13 must be approximately the same as the steam pressure to maintain the plunger 16 in equilibrium. Since there is a constant leakage past the piston 13, it will be seen



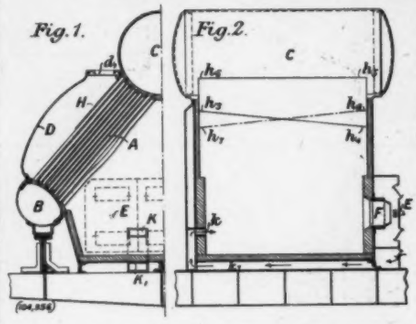
that the valve on the plunger 16 must be a certain small distance off its seat if equilibrium is to be maintained. Assuming that the pressure in the delivery main rises, the piston 13 will be forced downwards, thus closing the passage 15; this causes the pressure beneath the piston to build up, with the effect that the plunger 16 is pressed downwards so as to restore the opening to passage 15 to the amount necessary to re-establish equilibrium. The movement downwards of the piston 13 will close the steam valve, thus reducing the speed of the turbine sufficiently to restore the pressure in the delivery main to the proper amount. The action of the gear is similar when moving in an opposite direction if the water pressure is reduced. In this case, if the piston rises following a reduction in water pressure, the pressure in the space beneath the piston would tend to fall, causing the plunger 16 to rise and again throttle the passage 15 to the amount necessary to pass the leakage. (*Sealed.*)

105,716. James Howden and Company, Limited, and J. H. Hume, Glasgow. Steam Generators. (4 *Figs.*) October 21, 1916.—This invention relates to multi-sectional steam generators. A feature of the invention consists in the provision of an improved support for the lower drums comprising a rigid, preferably integral, plate constituting the front member of the furnace casing and formed with openings to receive the forward ends of the lower drums and also with door openings and apertures for admission of soot-cleaning devices. A secondary feature



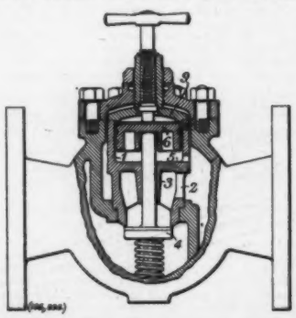
consists in the provision of access openings for soot-cleaning devices at the sides and rear of the combustion chamber. The extreme front wall of the furnace structure is constituted by an integral plate 11, which is formed with openings 12 to receive the forward ends of the lower drums 1, and also with openings 13 to be closed by the firing doors and with cut-away parts 14 to be closed by the furnace-cleaning doors and also with a row of orifices 15 for the passage of soot-cleaning devices, such orifices 15 being at the same level as a row of orifices 10 disposed horizontally in the walls of the furnace casing, which provide access for soot-cleaning devices to the sides and rear of the combustion chamber. To the boundaries of cut-away parts 16 are secured the sides of smoke-boxes 17, which are individual to each generator element; a manhole opening 18 cut in the plate being provided between adjacent smoke-boxes. (*Accepted May* 2, 1917.)

104,356. J. J. Kermode, Liverpool. Water-Tube Boilers. (9 *Figs.*) February 22, 1917.—This invention relates to water-tube boilers and consists of the combination with baffle plates adapted to give the maximum baffling effect, either in front or in rear of the boiler, of a regulatable auxiliary air supply which is led through suitable ducts to the back of the boiler and there mixes with the flame and gases. A are tubes, B the water drum, C the steam drum, D the wing casing, d^1 the opening to the up-take, E the burners. The baffle plate H may consist of one or a number of plates carried, say, by hooks and links. When the boiler is adapted to burn the liquid fuel in the form of a short intense flame, which fills the cone F, the shape of the lower edge of the baffle plate or plates is arranged as shown by the full line A^3, A^4, sloping downwardly towards the front, the configuration of the plate following the line A^3, A^4, A^5, A^6, and giving maximum baffling at the front end of the boiler, and so deflecting the flame and hot gas rearwardly, thus giving a more uniform distribution



of heat over the tubes and so avoiding the racking action on the tube plates which results from unequal heating, and at the same time protecting the brickwork at the front end from over-heating. When the liquid fuel is burned after the manner employed in the now well-known Kermode liquid fuel system, so as to produce a longer and wider flame which clears the cone and front brickwork, the edge of the baffle plate or plates is arranged as shown by the chain-dotted line A^7, A^8, the configuration of the plate following the lines A^5, A^6, A^7, A^8, which shape serves to spread the flame and hot gases into the wings at the front of the boiler. Baffle plates shaped in this way, according to the mode of firing to be adopted, give better and more economical results than are obtained with the ordinary construction, and the results are further improved by leading an auxiliary supply of air to the rear of the boiler; this is effected by providing an air inlet K at the rear of the boiler, to which air is supplied through the duct k^1. (*Sealed.*)

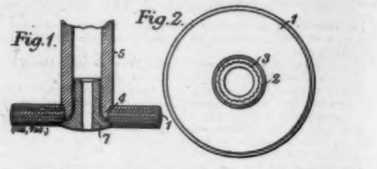
105,695. Cockburn's, Limited, D. Cockburn and D. MacNicoll, Cardonald, near Glasgow. Steam Valves. (3 *Figs.*) August 17, 1916.—This invention relates to steam valves in which there is provided a cage-member adapted continuously to present a true seating surface for engagement by the valve proper. The invention provides means comprising a flexible ring affording a joint between the cage-member and a ported cap fitted thereto and between the valve chest and its cover, the arrangement being such as to ensure tightness even with variable expansion. The valve-seating member is formed as a removable cage 1, provided with ports 2 for the passage of steam, said cage formed with a boss 3 presenting a guide for the



spindle of the valve proper 4 and with a partition 5 forming the lower end of a cylindrical cavity which serves to receive the piston 6 controlling the valve. The lower end of the cage presents a seating face for the valve 4. The seating member so constituted is admitted into the valve chest when the cover of the latter is removed, and is then surmounted by a dished cap 9, the lower face of which is normally substantially in the same plane as the joint-forming face of the cover, a flexible metallic ring being fitted to the joint of the valve chest and the cover and the joint of the cage 1 and its cap 9. The cap 9 is formed with a port or ports to admit fluid pressure to act on the piston serving to control the valve. (*Accepted May* 2, 1917.)

TEXTILE MACHINERY.

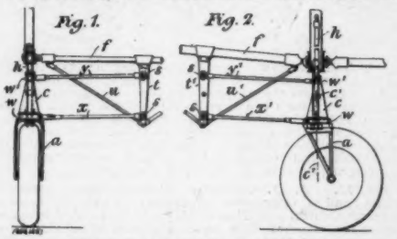
105,734. A. H. Briggs, Cottingley, near Bingley, and The R.C.V. Patent Bobbin Company (1914), Limited, Nottingham. Bobbins. (4 *Figs.*) January 5, 1917.—The present invention relates to bobbins for textile purposes, such as for drawing, spinning and like uses. According to the present invention, a bobbin head 1, preferably of multiple-ply wood, is perforated as usual, and the perforation 2 is scored axially as at 3; the head is then forced over the reduced end of a shank 5, usually hollow, the end of this shank being of slightly greater diameter than the diameter of the perforation 2, so that part of the material of this end of the shank will be displaced or forced into the scorings 3. The head will be keyed to the shank by a large number of flutings or ribs on the mutually-engaging parts, consequently any possible turning movement of the head relatively to the shank or barrel will be prevented. To more securely attach these parts, and also with the object of preventing



the heads slipping axially from the shank, a plug 7 may be driven in the hollow end of the shank, which plug is preferably made of a mushroom-shaped piece of wood usually having a central perforation, and which has forced or slipped on to it a split elastic metal sleeve tending to compress the shank of the said mushroom-shaped piece. (*Accepted May* 2, 1917.)

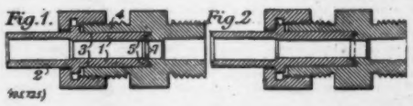
MISCELLANEOUS.

104,125. F. H. Royce, B. I. Day, and Rolls-Royce, Limited, Derby. Aircraft. (4 *Figs.*) September 15, 1916.—This invention relates to the mounting of the landing wheels on the chassis or framework of aircraft. The rings (or it may be the socket head) which form the swivel bearings for the wheel trunnion post to the framework of the aircraft are connected by means of radius rods arranged to be capable of movement in two vertical planes mutually at right angles, or approximately so. The top of the trunnion post is attached to a shock-absorbing device by means of a flexible joint, and joints are provided at both ends of the radius rods for the purpose of providing for the relative movements of the various parts. The trunnion post *c* and the fork *a*, which together form a rigid structure, are arranged to swivel in the bearings formed by the rings *w*, w^1 which encircle the trunnion post. The



centre of the landing wheel is located a certain distance away from the centre line c^1, c^1, of the trunnion post *c* in order to provide the necessary castor action. Attached to the post *c* are four radius rods *x*, x^1 and *y*, y^1, each one of an adjacent pair being disposed at right angles to its neighbour. Their inner ends are connected to the aircraft frame *f* by means of ball-and-socket joints *e* mounted upon the struts *t* and t^1, which are braced to the frame by means of the stays *u* and u^1 respectively. A thrust rod *h* is connected to the upper end of the trunnion post *c* by means of a ball-and-socket joint, and the upper end of the said thrust rod is coupled by means of another ball-and-socket joint to any suitable dash-pot, spring, or combination of the two, arranged to absorb the shock consequent upon landing or running over broken ground. (*Sealed.*)

105,725. R. A. Smith, Westminster. Disconnectible Pipe Couplings. (2 *Figs.*) November 29, 1916.—This invention relates to disconnectible pipe couplings of the spigot and socket kind. According to this invention, the projecting part 1 of the spigot member 2 is elongated, and fits within a correspondingly shaped recess 3 in the socket member 4. The part 1 and the recess 3 are of sufficient length (for example, one



and one-half or two times the diameter of the part 1) as to provide a substantially long bearing surface relatively to the diameter of the said part, which surface will act to maintain the said members in alignment. The end 5 of the part 1 is recessed to receive a projection 7 at the base of the recess 3, so that when the members are in position the projection 7 enters the recessed end 5 and forms an efficient metal to metal fluid-tight joint. (*Accepted May* 2, 1917.)

NITROGEN OXIDATION BY THE ELECTRIC DISCHARGE.—Emphasising that the nitrogen oxide formed by the arc flame should be quickly withdrawn from the hot zone and be rapidly cooled, lest it be decomposed again, Drs. H. Andriessen and Scheidemandel, of Munich, describe an arrangement of the flame arc which does not appear to differ very much from others in use. They place the two vertical electrodes parallel to one another, the one a little higher than the other, so that the arc strikes obliquely. Air is blown in through a vertical nozzle between the two electrodes, and the arc is thereby drawn out into a pointed flame; the flame is produced within the horizontal magnetic field, the electrodes being below the electromagnets. The magnetic deflection turns the flame into a spiral of small volume. The Birkeland-Eyde flame-disc is really also a spiral, but as their two electrodes are in alignment, their spiral forms a vertical disc about the electrodes as diameter. On the other hand, Pauling and others blow a current of air into the arc between electrodes, of the horn type, however. In a recent discourse (*Zeitschrift des Vereines Deutscher Ingenieure*, April 7, 1917) Andriessen claimed to obtain nearly twice as much NO by his arc than Birkeland-Eyde; there is no statement, however, as to the scale on which he has been experimenting.